Integrated intelligent LEARNing environment for Reading and Writing

D3.5 – Updated User Requirements, Learning Strategies Specifications and System Specifications

Document identifier	**D3.5_Updated_UserRequirements_LearningStrategies_final.docx**
Date	**2013-09-29**
WP	**WP3**
Partners	**DOLPHIN, NTUA, UoM, IoE, DYSACT, EPIRUS, LBUS**
WP Lead Partner	**NTUA**
Document status	**Final**

Deliverable Number	D3.5
Deliverable Title	Updated User Requirements, Learning Strategies Specifications and System Specifications
Deliverable version number	V0.1
Work package	WP3
Task	Task 3.1 User Requirements Analysis
Nature of the deliverable	Report (R)
Dissemination level	Public (PU)
Date of Version	2013-09-28

Author(s)	C. Litsas, A. Symvonis
Contributor(s)	A. Vasalou, D. Gooch, D. Lukes, M. Mastropavlou, V. Zakopoulou.
Reviewer(s)	A. Vasalou, A. Symvonis
Abstract	This deliverable provides an update of Deliverables D3.1 (User Requirements Analysis) and D3.2 (Learning Strategies Specification). A detailed description of learning activities is provided.
Keywords	Updated User Requirements, Updated Learning Strategies, Learning Activities.

Document Status Sheet

Issue	Date	Comment	Author
v01	2013-09-1	Document skeleton	C. Litsas
v02	2013-09-16	First version of User Requirements	D. Lukes
v03	2013-09-24	First version of Learning Strategies	M. Mastropavlou, V. Zakopoulou
v04	2013-09-26	Final version of User Requirements following review of A. Symvonis	A. Vasalou, D. Gooch
v05	2013-09-27	Final version of Learning Strategies following review of A. Vasalou	M. Mastropavlou
v06-final	2013-09-29	Final version	A. Symvonis, A. Litsas

Project information

Project acronym:	**ILearnRW**
Project full title:	**Integrated Intelligent Learning Environment for Reading and Writing**
Proposal/Contract no.:	**318803**

Project Officer: Krister Olson

Address:	L-2920 Luxembourg, Luxembourg
Phone:	+35 2430 134 332
E-mail:	krister.olson@ec.europa.eu

Project Co-ordinator: Noel Duffy

Address:	Dolphin Computer Access Ltd. Technology House, Blackpole Estate West, Worcester, UK. WR3 8TJ
Phone:	+01 905 754 577
Fax:	+01 905 754 559
E-mail:	noel.duffy@yourdolphin.com

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1. Introduction

The aim of this deliverable is to revise elements of the initial design of the iLearnRW system related to User Requirements Analysis , Learning Strategies and System Specification. The revision was anticipated due to the overlap of the User Modelling activities (Deliverable D4.1). The update is presented in an incremental way with respect to Deliverables D3.1 and D3.2, avoiding unnecessary repetition.

Section 2 presents the updated user requirements, as they were shaped by extensive user participation. In additions, a more detailed tentative description of the iLearnRW system is presented through the use of wireframes.

Section 3 presents the updated learning strategies employed by the iLearnRW system, following the development of the final user model. A set of learning activities adopted by the iLearnRW system, which address all the language areas/ difficulties included in a user profile, is presented. For each activity, a detailed description is provided at Appendix B.

No update of the System Specification described in Deliverable D3.3 was necessary.

2. User Requirements

2.1. Aims of the User Requirements Update

The update on the User Requirements is organised into two sub-sections:

Design research: the first aim of the user requirements update is to report on design research that was conducted mainly with teachers and to detail design activities undertaken within the project. The outcomes of this work have informed specific components of the project and resulted in new use cases.

This sub-section is split into three strands of work. The first one discusses design research conducted to understand the problem we aimed at addressing, the ways in which teachers typically assist children with dyslexia and how they believe technology can benefit children. The second strand describes design workshops with teachers where the user model was scoped and discusses how strategies used by teachers informed the model. The third strand details the design and specification of short educational activities intended to assist children in working on their particular difficulties, in which teachers' feedback was fed back into our specification.

The iLearn Application: the second aim of this updated deliverable is to present a more detailed specification of the iLearnRW software along with illustrative wireframes. Therefore, this section describes the software, how it is expected to behave and what principles underlay its features. It concludes with two additional use cases that complement those presented in the first deliverable.

2.2. Design Research

Within the iLearnRW project, the user requirements team has facilitated and led design research to support several project components. This section reports the entire programme of work undertaken noting that some of it will be presented in greater detail within specific deliverables.

2.2.1. Design Phase 1 – Exploring the Problem and Solution

At the start of ILearnRW, project partners with expertise in dyslexia education were key in describing the difficulties that children with dyslexia face within mainstream education. As a condition that manifests in different ways and with various levels of severity, it is often the case that children do not get properly diagnosed and, even if a diagnosis exists, they may not receive appropriate levels of support. This means that although the project focuses on children with dyslexia, we were careful to ensure that the software solution would be also useful to any child with literacy difficulties.

The first phase of our research aimed to develop this initial problem definition. A deeper understanding of the problem is essential to any project that seeks to provide a solution. Thus, first, we wanted to identify the particular challenges involved in dyslexic teaching as experienced by educators. To achieve this, it was necessary to consult specialist teachers who understood children's needs as well the constraints of mainstream education, and also mainstream teachers whose role oftentimes involved supporting undiagnosed children. Second, we wanted to capture the strategies that teachers employ when responding to the needs of individual children. While the teaching strategies documented in D3.2 mainly concern children's linguistic difficulties from an expert's perspective, they do not cover barriers in motivation for example, which are equally important to understand, nor do they consider what actually happens in literacy lessons when teacher exercise tacit knowledge to manage these difficulties. Focusing on how children's characteristics motivate teachers to employ particular teaching strategies was a requirement for developing the user-modelling component of the project (see deliverable D4.1). Third, we aimed at better defining the potential role that a learning technology could play in this space.

1.1.1.1 Methods

We undertook exploratory research observing two specialist teachers at Dyslexia Action (Bath and Chelmsford) conducting teaching interventions. Our observations lasted five hours in total. These teachers were interviewed as was the head of the Chelmsford Dyslexia Action centre. Additionally, we interviewed mainstream teachers and SEN teachers at two different schools (London and Chelmsford). Detailed notes were taken of all sessions and observations, and where permission was given, audio recordings were also obtained. The insights reported below are based on the experiences and observed practices of these eight participants.

1.1.1.2 Key findings

Problem definition: We discovered that schools do not have a well-developed strategy to support children with dyslexia. When it comes to using global literacy programs, the lack of understanding of dyslexia means that useful technological resources that can assist children are not identified. For example, literacy computer games chosen by schools can be dry and boring, the text presented within them does not appeal to children's interest and the presentation of text is overwhelming. The absence of a sound teaching programme is also evident within teaching practice: teachers who lack specialist training may advise children to practice more, without providing strategies to help them overcome their difficulties. At the same time, teachers with training lack the time to truly personalise teaching sessions to appeal to a child's interests. In considering education from a broader perspective, our teachers emphasised the importance of learning at home to note that many children were not motivated to learn outside school while some parents' literacy levels impeded on their desire to help their children. Therefore, this is a multi-faceted problem characterised by a **lack of expertise, time** and **resources** that **cuts across formal** and **informal learning contexts**.

Benefits of technology: In light of these challenges, our participants believed that technology based on portable tablet computers could achieve several high-level goals:

(1) **Encapsulate best teaching practice tailored** to support children, as well as scaffold tutor support during one-to-one tutoring e.g. with teachers, parents
(2) **Create integrated support** by bridging the home and school, and thus encouraging more communication between informal and formal learning contexts
(3) **Mitigate exclusion due to reading barriers** by exposing children to complex vocabulary through text-to-speech capabilities
(4) **Provide a neutral territory** that depersonalises learning and helps children be more resilient during failure.

Most importantly, teachers' views elaborated on the learning goals we had initially defined for our project, by reaffirming the need to develop children's individual linguistic and cognitive challenges (D3.1, §7.2.2 and D3.1, §7.2.3), and the ways in which these could be achieved (see D3.1) by designing technologies around real world constraints across different learning contexts (D3.1, §8.5), supporting inclusion in learning (D3.1, §8.4), and boosting children's self-esteem (D3.1, §7.2.1).

Teaching Strategies: In examining what constitutes best teaching practice, we found that many of these inspirational principles were already achieved by teachers through a series of strategies: they personalised teaching to a child's linguistic difficulties, they supported meta-cognitive strategies, worked to increase children's motivation, and bolstered children's confidence. Table 1 summarises the fine-grained teaching strategies employed by teachers and demonstrates how they accomplish each of these educational goals. It also indicates which strategies we are directly employing within the ILearnRW software. We note that a single strategy can fulfil multiple purposes. For example, the

variety of a short succession of activities motivates children by keeping their interest levels high and also creates an environment in which children can better monitor their own progress.

	Motivation	Meta-cognition	Personalisa-tion	Confi-dence	Used in iLearnRW
Provide a succession of short activities	✓	✓			✓
Link reading to the child's own interests	✓				✓
Set short-term objectives that are easy to remember	✓				
Link with the creative curriculum which children often excel at	✓				
Never say something is wrong but rather focus on teaching the strategy to correct it		✓		✓	✓
Focus on the one most important thing to improve	✓		✓	✓	✓
Only focus on teaching rules of key words that are spelled incorrectly (not all words)		✓		✓	
Provide the child with a strategy for discovering the correct answer, e.g. by highlighting part of the text and providing strategy		✓			
Children are not allowed to move on without understanding what they did wrong		✓			
Establish a sense of personal progress, e.g. having a visual rundown of activities and the children have to mark off activities completed, children fill in own progress sheets, create charts of longitudinal progress	✓	✓		✓	✓
Encourage children to say everything out loud		✓			
Allow a child to beat their previous performance by looking forward as well as back	✓	✓		✓	✓
Encourage children to think about the strategies they are using to find the correct answers		✓			
Set small achievable targets focused on the one most important thing to move the child forward, which means they rarely ever 'fail'	✓			✓	✓

Date: 2013/09/29
Project: ILearnRW
Doc.Identifier:FINAL_ILearnRW_D3.5_Updated_UserRequirements_LearningStrategies.doc
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Start with presenting progress and then present areas of weakness		✓		✓	
Allow children to decide when they are ready to go up to the next level		✓		✓	✓
Don't give praise for praise sake				✓	✓
Be sure that new content is presented at the same time as familiar content or within a familiar structure		✓			✓
Always finish in a positive note				✓	
If a child gets something right that is often challenging for others, let them know				✓	✓
Provide personalised word lists			✓		✓
If a child cannot understand a particular concept then try a different teaching approach		✓	✓		
Multisensory teaching		✓	✓		✓
Learning aim made explicit at start of lesson	✓	✓			✓

Table 1. Summary of Teaching Strategies

2.2.2. Design Phase 2 – Designing the User Model

A key mechanism for delivering the ILearnRW teaching strategies is *personalisation*. People are complex and modelling them could be a limitless endeavour. This is especially the case in light of children's vast and variable linguistic difficulties, which is the key focus of this project.

A series of design activities were involved in scoping the user model. A one-day focus group was held with 5 Dyslexia Action (DA) teachers (and 1 Dyslexia Action teacher trainer). The aim of the workshop was to identify and agree on **priority areas of linguistic difficulty** to be addressed within ILearnRW. Teachers highlighted the nine most important linguistic difficulties that children typically encounter with learning English, namely *Syllable Division, Vowel Sounds, Suffixing, Prefixing, Grapheme/ Phoneme Correspondence, Letter patterns, Letter names, Irregular/sight words,* and *Confusing letter shapes*.

To enable us to **identify how to adapt the system** in response to these difficulties, we then conducted a comprehensive review on several literacy programmes starting with the Dyslexia Institute Literacy Program (DILP) [Walker et al., 2008], Units of Sound 1, 2 and 3 [Bramley, 2004], Alpha to Omega [Hornsby et. al, 1999] and the Dyslexia Portfolio [Turner, 2008]. This yielded a first version of the user model. After this initial and necessary stage had been completed and documented, we consulted the exploratory research conducted within the first phase of our project to **broaden our understanding of the individual needs** that children with dyslexia have. This research pointed to additional characteristics and strategies employed during interventions, such as building up a child's self-esteem or fitting the activity to the child's interests (see Table 1). Given the time constraints and resources of our project, only a few of these additional characteristics folded back into the user model. Deliverable D4.1 (Section 5) presents the design work undertaken to develop the user-model in more detail.

2.2.3.   Phase 3 – Designing Learning Activities

A key teaching strategy typically employed within specialist sessions is to present children with a succession of short learning activities. This captures children's interest and avoids spending too much time on difficult activities. Basing our project on this approach, it was decided that the ILearnRW software would include a *series of short activities that will help children understand and apply linguistic rules concerning specific areas of difficulty*. In having scoped the key difficulties our project would address (see design phase 2), two workshops were held between Dyslexia Action and London Knowledge Lab teams, the aim of which was to develop an initial set of learning activities. Our team comprised of five project members in total, with expertise in teaching for dyslexia, linguistics, programming, user-centred design and user modelling.

The approach we took to design these learning activities was to base them on existing best practice. We mainly drew inspiration from the DILP teaching programme that is championed within Dyslexia Action. Our workshops yielded a total of eleven tentative activities. We created wireframes for each activity and specified mechanics. Each activity was thus characterised by aesthetics and learning mechanics. Having a concrete description and low fidelity prototype for each activity was imperative to share with teachers and other partners within the project. Figure 1 presents an example output from this work.
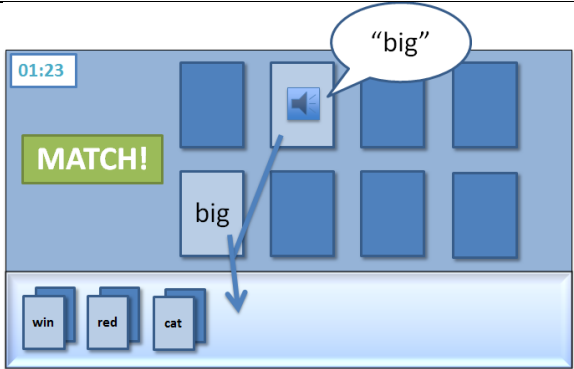
Wireframe	Example Mechanics
	▪ An animated finger appears that taps on a single card and it turns over to reveal the word "big" ▪ Then, the finger taps on a second card, which turns over with a sound icon on it and the word "pig" is pronounced. ▪ The finger taps on the second card again, to indicate that it thinks that the cards match. ▪ The words "No Match" and an icon with a cross appear to the side of the grid …

Figure 1. Example Learning Activity (Pelmanism/Matching Game)

2.2.4.   Teacher Feedback

We shared our wireframes and detailed descriptions with special education needs teachers at two schools: in Northampton (Midlands) and Peckham (London). Our questions to teachers were posed to answer whether the design of the activities would pose barriers to children, if the teaching strategies used were based on sound principles and if the nature of the activity would be motivating for children.

We summarise our key findings:

Text presentation: Some of teachers' suggestions centred on visual presentation. Teachers pointed out the need to use a dyslexia friendly font as well as to be careful with use of capitals. The use of lower case was encouraged as children often have difficulties with visual discrimination.

Pedagogy and Metacognition: All teachers agreed that the option of a timer was appropriate in encouraging fluency and also enabling students to measure their improvement. Nonetheless, one of

them suggested the inclusion of an option that would allow the child to decide whether or to have their performance timed to avoid impeding on their self-confidence.

The greatest concern echoed across all teachers was providing the appropriate feedback to the student at the appropriate moments. Teachers emphasised that activities needed to provide an explanation to the child as to why they failed or succeeded, while explicitly providing an explanation of the rule that is being practiced and why it is important. If a child was unable to complete an activity, they proposed providing different strategies, and to enable the child to freely have a go. Further, when a child applied the correct rule, teachers highlighted the importance to acknowledge its application.

The feedback we gathered led to a further refinement of the activities, which were shared with project partners, and led to more refinements in order to align them with the Greek language. The final output of this work – including the teaching strategy underpinning each activity, the mechanics on which it operates, and visual wireframes – are all reported within the **updated teaching strategies section** within the current deliverable. We note that the specification of activities will be adapted to fit with the narrative of the game component of iLearnRW.

2.2.5. Summary of Research Outcomes

The outcomes of our design work and research were both direct and indirect. Directly, they informed the design of the user model and the learning activities. They also led to the proposal of new use cases. Indirectly, our research reaffirmed our conviction to develop a learning, rather than assistive, suite of tools. Cumulatively they pointed to consistent patterns of teaching strategies and recommendations. Therefore, alongside the expert-driven guidelines identified in Deliverable 3.1 (section 10.5), our research reveals a set of practice-informed guidelines, which are considered during the design of ILearnRW. These are:

Pedagogical guidelines
- Promote self-discovery and metacognitive strategies through guided instructions
- Promote the development of fluency by giving users options to measure their performance
- Take into account the stressful nature of literacy difficulties and make timing of activities optional
- Do not increase cognitive load by playing audio in the background for phonological tasks
- Provide motivation through a system of rewards and encouragement
- Provide detailed and timely feedback on progress
- Make it possible to link progress through the system to progress in school-based literacy instruction

User interaction guidelines
Interactions between the user and the system should be designed in such a way as to minimise the processing load of users who have dyslexic type difficulties, which may include working memory and speed of processing
- Dyslexia-friendly presentation of text
- Provide an audio option for all text instructions
- Provide clear navigation throughout the system
- Present instructions in small chunks, ideally with graphical overlay.

So far we have detailed our design research and process. The remainder of the user requirements update will present the design vision and specification of the ILearnRW software.

2.3. The ILearnRW Application

2.3.1.   System Overview

The iLearnRW system comprises of three modes: play, read and adventure (see
Figure 2). The learning activities developed during our design research constitute the core learning
component of the project. These activities will be shared across the entire system. In the play mode,
the activities will be directly accessed through an interactive interface. When a child launches the read
mode, the system will provide pre-reading activities, thus reinforcing the integrated nature of the
acquisition of reading and writing skills. Similarly, the learning activities will be embedded into the
serious game launched from the adventure mode.
Figure 2 summarises how these components interconnect across the project. Given the on-going
development of the game design deliverable, in this deliverable we will focus on describing the play
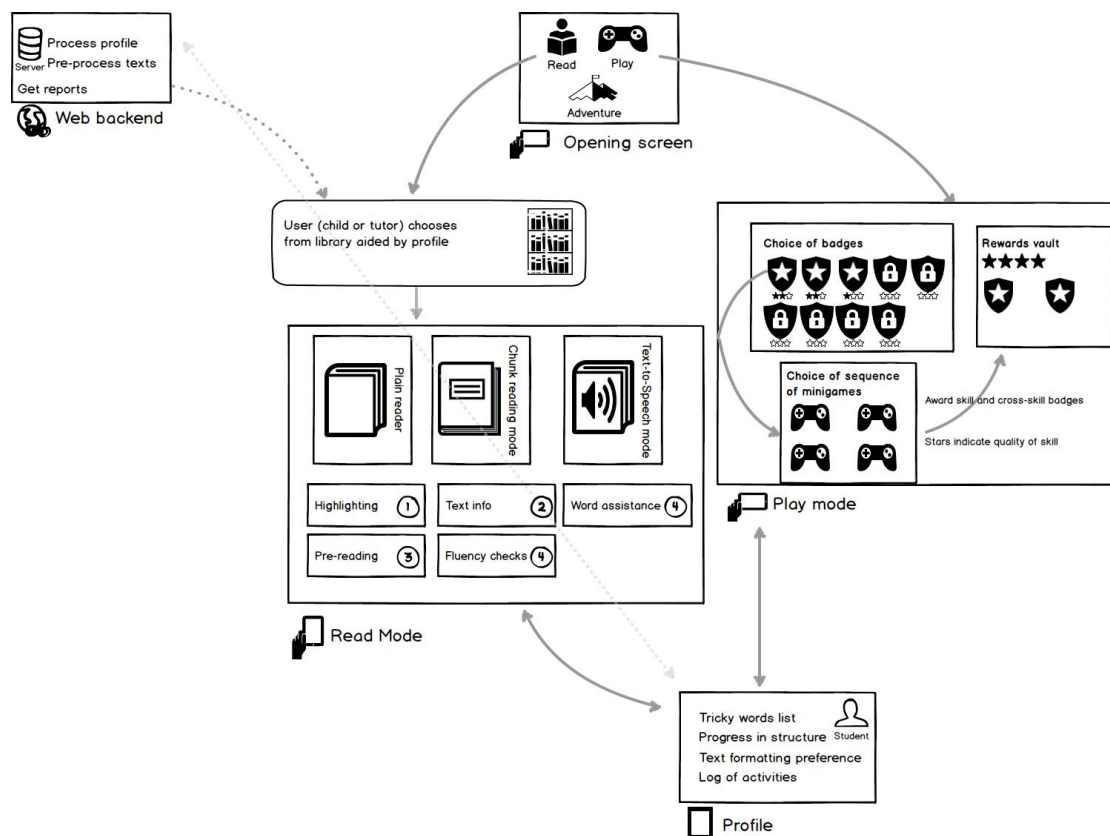and read modes only.

Figure 2. System Overview

2.3.2.   Play mode

When the child enters the play mode, an interface will direct them to choose which learning activities
to play. Each activity will be chosen on the basis of their profile. Activities completed will be

recorded and the system will update the child's on-going progress. After an activity has been accomplished, the same interface will visualize the child's progress to motivate them into further continuing and to promote metacognition (also see the User Modelling Deliverable D4.1, Section 9 for more detail). This interface will be informed by design research with teachers and students over the coming months, and will draw on the expertise of our game design team in Malta to pick out how rewards and achievements are best designed. Here, we detail an initial design concept that attempts to balance a practical method for navigating and choosing activities, with a way to motivate children to complete activities and promote metacognitive skills in helping them recognise what they have learned.

Upon entering the play mode, the child will access a *dashboard* (see Figure 3). The dashboard will enable the child to launch activities as a means to gaining specific achievements. Each achievement will be represented in the form of a badge corresponding to an area of linguistic difficulty stored in the profile. Stars will indicate progress within each badge. Initially, all badges will be unavailable to the user (using a lock icon) except for the first one, which will be unlocked. The user will have to achieve at least one star on the initial badge to 'unlock' the next badge in line.
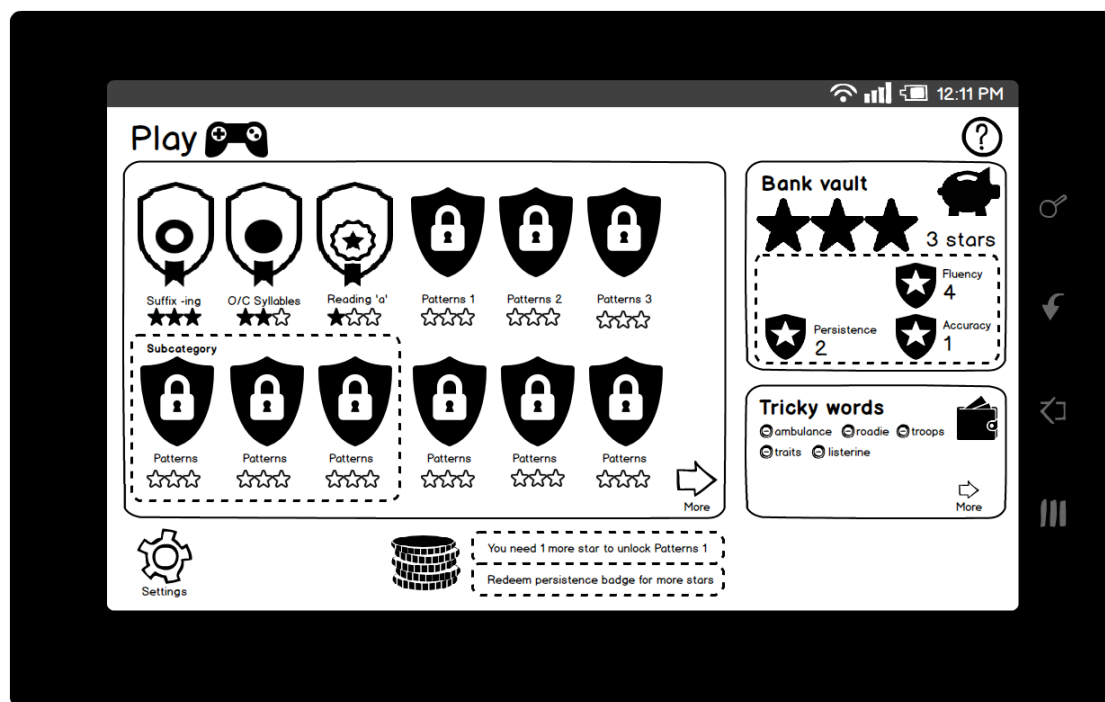

Figure 3. Play Mode

When the user taps the badge icon, a pop up screen will be selected with four learning activities chosen on the basis of the profile. The child will be able to play each one to earn a star and unlock the next activity (see Figure 4).
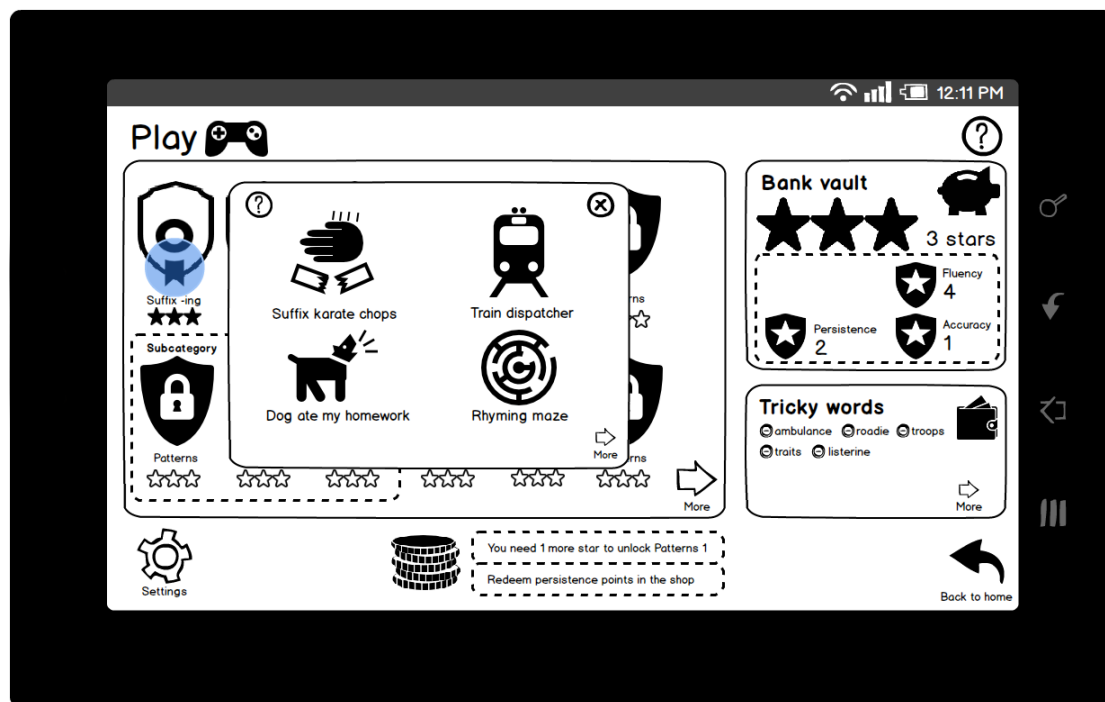
Figure 4. Learning Activities

When children have unlocked a new badge they will have a choice of playing more games to achieve stars on that particular badge or they will return to one of the previous badges and try to achieve more stars on them. The unlocking of new badges will not be linear but cumulative. Therefore, new badges will be unlocked for a total number of stars, not simply for a total number previous badges unlocked. This will ensure that students are required to return and improve their skills with badges that had been already unlocked but only one star was achieved. This approach is intended to provide realistic game motivation for achieving learning over the long term. Such a system fits with the principle of "overlearning" which is detailed in the Teaching strategies deliverable D3.2.

The right-hand side column of Figure 3 contains rewards vaults that summarise cumulative achievements not linked to individual difficulties. These will be the total number of stars as well as badges linked to metacognition aspects such as persistence (playing activities with the same linguistic difficulty over time) and skills not related to phonic structure sequence such as fluency and accuracy, gathered from time spent in the reader. This is important for two reasons. First, users struggling with the achievement of badges related to basic skills can gain other achievements, thus preserving their motivation in the face of struggle. Second, there are a number of skills related to reading and writing that cannot be captured by a linear indication of progress. Furthermore, this combination of linear progress and non-linear achievement is a readily recognisable part of the gaming idiom and thus likely to present little difficulty for users. Additionally, the Rewards area will contain other indicators of progress such as a list of tricky words previously encountered in the reader (see read mode for more details on this feature), which the users can remove by choosing to tackle through individual learning activities.

Finally, the interface will feature an area for feedback (see bottom part of Figure 3). Although the interface will indicate levels of progress in a way that is both intuitive and consistent with the prevailing game idiom, it will be necessary to provide detailed instructions to user as to how exactly rewards can be utilised. While it will be obvious to the user what to do in order to play the next activity, an indication of cumulative progress needs to be given. Users will also need encouragement to try new things. Messages such as 'Try to get more stars for badge X' will be necessary to give them guidance.

2.3.3. Read mode

The read mode is essential for providing literacy development in the context of real reading: even though children might learn how a rule applies on a single word, they must implement this knowledge during the reading of longer texts. This underscores our understanding of reading as transcending simple phonology. In designing the reader we had to distinguish between two dimensions: the reader acting as a *learning tool* and the reader supporting reading activities as an *access tool*. These dimensions are not mutually exclusive since supporting access to text is a barrier that must be overcome before focusing on children's linguistic difficulties. However, it is important to note that our project priority is to develop a learning tool whose main strategy is to personalise teaching strategies to each child's linguistic difficulties. Accessibility will be a parallel, but yet secondary aim. As such, this description will prioritise features accordingly.

The reader will aim to implement the features outlined in Table 2. We have made clear which features belong to our learning aims, our assistive aims and which features relate only to the concept of the software being a "reader". We have also classified the features as being of higher or lower priority based on whether they are related to the educational aims or the project or if they are connected to the personalised strategies which the profile is key to delivering. Our aim is to deliver all high priority features. Lower priority features will not be the focus of this project. Given the priority levels of the various features, the lower priority assistive features and all reader features are presented in Appendix A.

	Learning	Assistive	Reader
	Higher priority	**Higher priority**	**Higher priority**
Easy to implement	Text guidance to highlight key difficulties contained in the text in relation to the user profile Linking to individual learning activities	Text style settings Listen interface for text-to-speech	
Hard to implement	Single word popup assistance	Single word popup assistance	
	Lower priority	**Lower priority**	**Lower priority**
	• Pre-reading information screen	• Text information screen	User help overlay General settings screen
		Chunking interface to display the text in smaller segments	Bookmarking, highlighting and annotations Table of contents screen

Table 2. Main Features of the Reader Organised by Type, Functionality and Ease of Implementation.

Throughout this deliverable we use wireframe images to demonstrate how certain features might be realised within the project. They are for illustrative purposes only and do not necessarily represent how certain features will be implemented within the reader software. Although our aim is to follow these design proposals as closely as possible, the implementation will in large part depend on what is technically feasible. With this in mind, Figure 5 demonstrates the read mode. The top menu bar provides access to various reading functions while the bottom menu bar contains the access point to

the learning and assistive features. We will now discuss each of the features in turn. We will begin by discussing the learning features before moving on to discuss the high priority assistive features. Features deemed as lower priority (see Table 2) are presented in Appendix A.
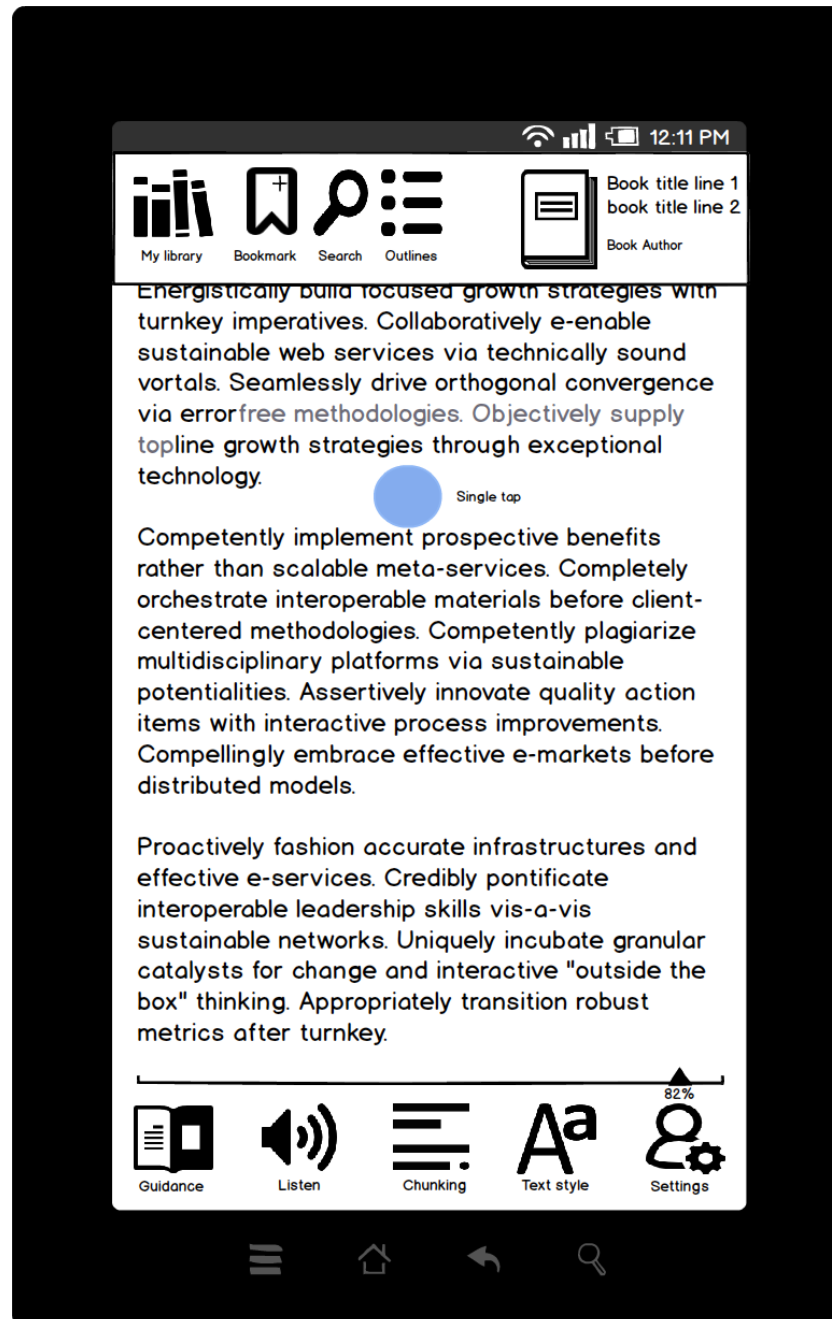

Figure 5. Reader Wireframe

2.3.4. Learning Features

The learner features are the nexus of the integration of reading and learning, engaging the user in three key elements of learning: (1) Phonic awareness (2) Fluency development and (3) Metacognitive strategies. Table 3 summarises how the specific features of the reader are aligned with these learning elements. We next discuss each feature in turn, briefly describing it and why it is useful in supporting children with dyslexia.

	Phonic awareness	Fluency development	Metacognitive strategies
Highlighting of phonic elements through the overlays	✓		✓
Link to the individual learning activities	✓		✓
Single word popup	✓		
Pre-reading activities	✓	✓	✓

Table 3. Breakdown of how Each Learning Feature is Linked to Specific Aspects of Linguistic Developments

Text guidance/overlays
This feature is intended to highlight key difficulties contained in the text in relation to the user profile. For example, if a child's profile indicates that they are currently working on the "ing" suffix, the child can deploy the "ing" overlay, which highlights all words on the current page. This is presumed to be useful as it scaffolds the child's ability to break down the word into its component parts. There are a variety of different methods of highlighting text. Some examples include:

> Words are highlighted
> Words are **bolded**
> Parts of words are bold**ed**
> Parts of words are lighter (vs. corner vs. prefaced)
> Parts of words are highlighted
> Parts of words have increased kern i n g
> Parts of words are underlin<u>ed</u> (not <u>u</u> but light dotted line with space under the text)
> Based on the difficulties captured in the profile, the following types of phonic and morphophonemic structures can be highlighted:
> Suffixes and suffixing rules
> Types of phonemes (e.g. schwa, long/short vowels)
> Particular pronunciation of letters (e.g. 'a' pronounced as in 'cane')
> Particular spelling patterns with specific pronunciations (e.g. 'ure' pronounced in as in 'sure')
> Types of syllables (e.g. open/closed)
> Silent letters (e.g. knowledge, Mike)
> Sign words
> Syllable

As a brief aside, many dyslexic readers prefer more spacing. Character spacing is one way to give word structure more prominence without confusing the user visually. This is what is meant by 'kerning'. Technically, kerning is different from letter spacing, however, in this document they are used interchangeably. Increasing character spacing between individual letters can introduce confusion with word spacing and should be used with caution.
The amount of highlighting will be capped so that the child is not overwhelmed by the text. Similarly, only one overlay can be used at once to prevent an overly confusing presentation of the text. The amount of highlighting is likely to be calculated based on the number of features present in the text

and the level of highlighting set by the user. The default levels range from one highlight per sentence to one highlight per word.

Given that there are multiple ways to highlight text, one option we are considering is to allow the user to set the type of highlighting for each phonic feature with which they need help. This feature is demonstrated in Figure 6.
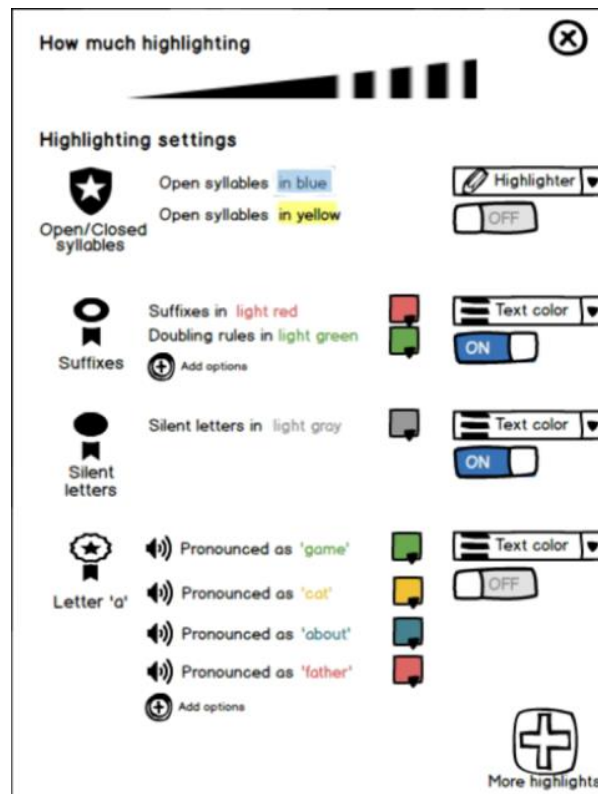
Figure 6. Highlighting Settings

Link to individual learning activities
This feature allows a child to access the individual learning activities from the text they are reading. This is such that they can practice skills, which are necessary in the text currently being read. For example, if a given text contains a lot of suffixes, the child might like to play some learning activities based on suffixing before attempting to go back to the text to read it.

Single word popup
This learning feature is designed to provide help about a specific word. It has both learning and assistive features, which we shall discuss here. This popup appears when a single word is selected using the standard android operation of tap and hold. The primary purpose of the screen is to display information about the selected word (see
Figure 7).

Figure 7. Single Word Popup

This feature presents a **pronunciation guide** (visually and auditory), alongside definitions of the word, to assist readers who simply do not know what the word means. Breaking the word up by **syllables, phonemes and letters** helps readers who are attempting to read the word by breaking it up into segments. The auditory options for this are also useful as the child can listen to how the spoken word is created from smaller parts. The popup will also include a mechanism for the reader to add the word to their "**tricky word**" list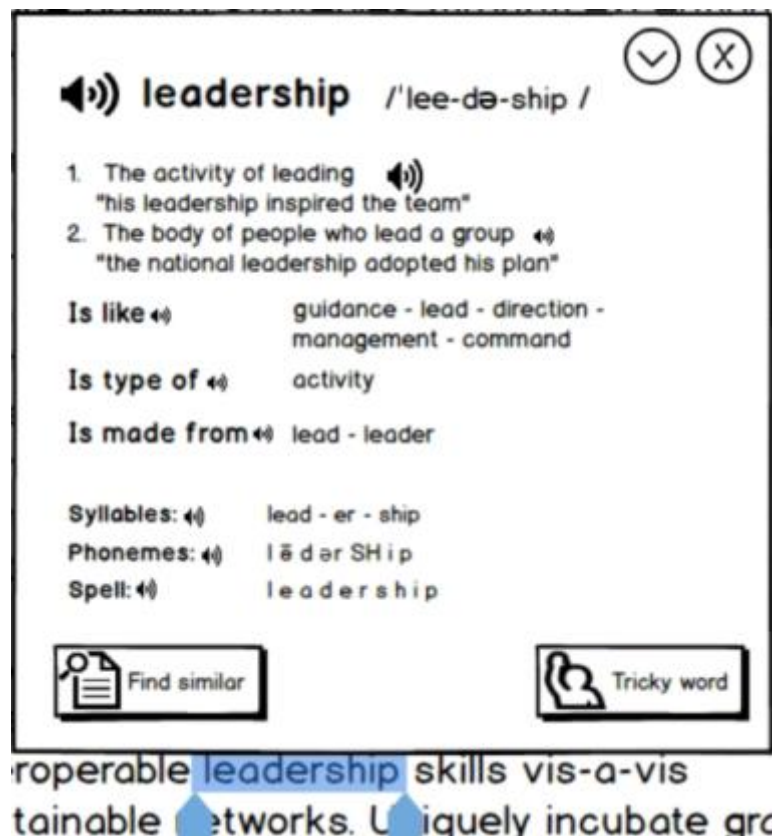 in the profile. This marks the word as being particularly difficult for this specific child. Children can subsequently work on these words through focused learning activities within the play mode (see Figure 3).

Pre-reading information screen

Pre-reading activities are intended to help readers familiarize themselves with key elements of the text that may present a challenge so as not to impede decoding once the reader reads the whole text. This includes reviewing potentially tricky words and making judgments about what the reading is about. After extensive discussions around the feasibility of including pre-reading activities, we have decided that presenting key information about the text is a low priority feature. The key information likely to appear in the pre-reading information screen includes:

A list of the tricky words appearing in the text

A list of potentially difficult words and patterns based on the child's profile

A list of the most common words in the text (to help estimate the meaning)

Reviewing a list of document section and subsection headings if present

2.3.5. Assistive Features

There are five assistive features within the reader. Changing text style and text to speech settings are high priority features, which will be implemented by the reader. We have already discussed the assistive features of the single word popup. The chunking interface and the text information screen are low priority features (presented in Appendix A), which are unlikely to be implemented within the system.

Text style settings screen

Within any digital reader it is necessary to consider how to display text. As we are providing texts to children who have difficulties with reading to begin with, it becomes even more important. The following default text style settings are derived from the best practice outlined by [Smythe, 2010]:

Line spacing: Default set to 1.25
Line length: Default set to 65 characters.
Font face: Default set to Tahoma
Text size: Very small, Small, Smaller, Normal, Larger, Large, Very large. Text size is not defined by absolute points but rather by relative size to avoid difficulties with visible size of different type facing.
Font face: Choose from fonts available on the system.
Contrast presets define values for High contrast, Med contrast, Low contrast.
Text colour
Background colour

It will also be necessary to change the contrast of the foreground/background colours. In order to minimise the effort involved in experimenting with the numerous text style settings, we are considering implementing 3 spacing pre-sets. Each pre-set combines a series of default settings to result in a roomy, comfy or cozy presentation of the text. The proposed default settings are:

Roomy: Line spacing: 1.5, Line length: 55, Character spacing: 1.2, Text size: 120%, Lines per page: 30
Comfy: Line spacing: 1.25, Line length: 65, Character spacing: 1.1, Text size: 120%, Lines per page: 40
Cozy: Line spacing: 1, Line length: 75, Character spacing: 1, Text size: 120%, Lines per page: 50

Text to speech features
The purpose of the text to speech feature is to make it possible for students to access the text without having to read it. This is a significant feature, necessary for any reader targeted at dyslexic users since it introduces them to richer and age appropriate vocabulary. Given the necessity of a text to speech feature, it is necessary to considering the settings of how such a feature would work. The various settings needed include:

Play/Pause: Pause/resume playback. The default state of this setting is pause.
Stop: Stop playback and close the listen mode.
FastForward/Jump forward: Jump to previous sentence or word (can be configured in Settings)
Rewind/Jump back: Jump to previous sentence or word (can be configured in Settings)
Speed slider: Increase / decrease playback speed
Pitch slider: Increase / decrease voice pitch
Voice dropdown: Choose Text-to-Speech voice

Volume slider: Increase / decrease volume

Figure 8 shows what the text-to-speech feature may look like.
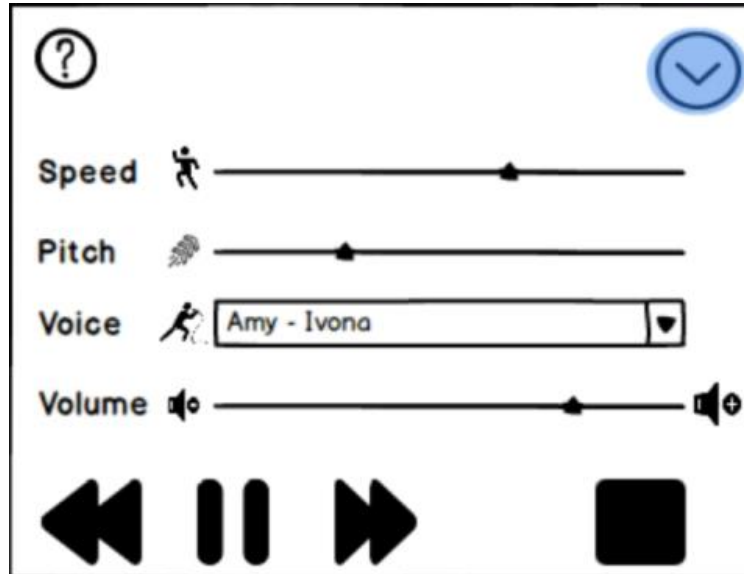
Figure 8. Text to Speech

2.3.6. Use Cases

Use cases provide further means of gathering requirements. In D3.1 we had proposed two use cases mainly centred on the operation of the read mode. Here, we focus our use cases on the play and adventure mode to capture the benefit that iLearnRW can bring within formal education settings, as well as how structured play can work side by side with leisure play.

Use Case 3: Facilitating Learning in Teacher-Student Sessions
1. The child clicks on the play mode
2. Badges of previous game play earned appear. Some badges feature only two stars indicating that more progress can be made
3. The teacher appraises the child's progress based on the badges and stars earned to propose that they work on previous difficulties as opposed to moving on
4. The child clicks on a badge and is presented with a set of four learning activities based on the user profile
5. Based on her knowledge of the student, the teacher recommends the bridge builder learning activity
6. Steps 3 to 5 are repeated and after a series of short activities have been completed the tutoring session comes to and end
7. The teacher writes up a small report for the child's parent to indicate which activities in particular require more revision at home.

Use Case 4: Moving from Play to Adventure Mode
1. The child has mastered suffixing in the play mode during one-to-one tutoring, or on their own

2. After earning this new badge, a visual cue appears in the dashboard to indicate that new discoveries have been added within the game as a consequence

3. Later when at home, the child launches the adventure mode and immediately enters a quest that presents new game world discoveries that occasionally interweave learning activities on the skill previously mastered, *suffixing*

4. As each suffixing activity is completed, an updated badge briefly appears over the player's character

5. After exploring the world for a while, an event prompts the child to consider taking a new learning challenge to progress deeper within the world. The child can choose to take on the challenge or continue on within the world as it stands

6. The child decides to take up the new challenge within the game which involves *syllabification* and to unlock new aspects of the world

7. When the child later returns to the play mode, one star has been added to the syllabification badge and a star has been added to the explorer badge.

3. Learning Strategies Specifications

In this Section, we update the learning strategies of the iLearnRW learning system, after revising the initial design prepared for Deliverable 3.2 in month 6. Compared to the initial learning approach presented in Deliverable 3.2, a number of revisions were made so as to produce a more functional and effective learning tool. These revisions mainly involve the classification of the language areas to be targeted by iLearnRW as well as the user profile entries.

3.1. Classification of language areas / difficulties

The initial description of the language areas that pose difficulties for students with dyslexia included a rather large number of entries and an even larger number of sub-categories. Specifically, the initial profile comprised a number of linguistic categories, namely phonology, word recognition and morphology, which were dealt separately for reading and writing, while a sentence/text level was also included. Each of these categories included a number of sub-categories, which corresponded to specific instances of errors associated with each category. For instance, the Phonology level in Reading included auditory-based and visual-based letter recognition, letter reversals, substitutions, omissions and additions. This classification, however, proved problematic in its implementation as it was considered more detailed than necessary, which constituted the building of activities to address each of the specific sub-categories not feasible. Therefore, a broader classification of language areas to be addressed by iLearnRW was created, so that most of the areas of the initial classification would fall within one of the broader levels of the revised one. The selection of the linguistic areas included was based on information on most intense difficulties exhibited by children with dyslexia, drawn from the literature as well as from special education teachers (see Deliverable 3.1, User Requirements). Additionally, reading and spelling are not treated differently in the new scheme, while the sentence/text level was removed as a whole, so as to ensure greater focus and thus greater effectiveness of the software. The linguistic categories of the initial and the new profile are illustrated in Table 4.

Initial profile	Revised profile / English	Revised profile / Greek
READING - Phonology - Word recognition - Morphology **SPELLING** - Visual/Phonological errors - *Auditory errors* - *Visual errors* - Grammar - Sentence / Text	1. Syllable division	1. Syllable division
	2. Vowel sounds	2. Phonemes: Consonants
	3. Suffixing	3. Phonemes: Vowels
	4. Prefixing	4. Derivational suffixing
	5. Grapheme-phoneme correspondence	5. Inflectional suffixing
	6. Letter / word patterns	6. Prefixing
	7. Letter names	7. Grapheme-phoneme correspondence
	8. Irregular/sight words	8. Grammar: function words
	9. Confusing letter shapes	9. Word recognition: sight & irregular words
		10. Letter visual similarity

Table 4 Language areas included in the old and the revised profile

Note that the sub-categories of the initial profile have not been included in this table.

3.2. Language areas and user profile entries

A significant change made to the initial intervention model described in Deliverable D3.2 involves the way the set of language areas (or difficulties) relate to the user profile. In the initial version, the language areas were mapped onto a set of user profile entries, which roughly corresponded to the language areas targeted. In the revised version, the set of language areas also constitutes the user profile entries, which will be used to 'place' each learner on a particular developmental level with respect to each language area targeted.

Each language area, and thus profile entry, now includes a number of levels marked with an index. Each of these levels corresponds to a specific instance or category of instances in which the particular language difficulty is manifested. For instance, the linguistic area of Prefixing (Greek version) is associated with 6 levels, marked with an index from 1 to 6, which include adjectival prefixes that denote privative, opposite or difficulty (level 1), nominal prefixes that denote quantity (level 2) and so on (see Greek profile in Appendix 1). The index associated with each level denotes its difficulty or complexity, which was defined in terms of learnability and was determined based on empirical evidence available in the literature. This means that the levels associated with a language area have been ordered in terms of increasing difficulty, while the index constitutes a difficulty/complexity scale. This is illustrated in the Greek profile excerpt in Table 5.

	Index					
	1	2	3	4	5	6
Prefixing	**ADJS:** Privative/ Opposite/ Difficulty: α-, αντι-, δυσ-	**ADJS& NOUNS:** Quantity (over/under): υπερ-/υπο-, κατα-	**VERBS:** Quantity (over/under):	**Lexical prefixes:** δι-/τρι-, πρωτο-, αυτο-, πολυ-, μικρο-, ψιλο-, ημι-	**VERBS:** ανα-, αντι-, απο-, δια-, εισ-, εκ-/εξ-, εν-, επι-, κατα-, μετα-, παρα-, περι-, προ-, προσ-, συν-	**VERBS:** Lexical prefixes: ψιλο-, μισο-, κουτσο-, ψευτο-

Table 5. Index Numbers and Levels Associated with the Language Area/Difficulty of Prefixing (Greek Profile)

The order in which the levels of the category Prefix have been placed in the table and the index associated with each of them denotes their inherent difficulty in terms of learnability. Therefore, verbal prefixes are placed higher in the scale as verbs are inherently more complex than nominal categories (nouns and adjectives), while the adjectival prefixes that denote a privative or opposite meaning as well as difficulty are the most frequent and thus easier to learn.

Upon (or before) first use of the iLearnRW tool, the child undergoes a short screening procedure with an expert in dyslexia and is assigned a severity score on each language area. This severity score will be used to indicate which language areas are not problematic for the child, so that they are not presented in the activities. This is essential as there is a wide range of linguistic skills covered by the language areas included in the user profile, which range from very basic (i.e. letter identification) to rather advanced (i.e. identifying the appropriate suffix to establish syntactic agreement in a phrase). If no information on the individualised skills and weaknesses is available at the beginning of using iLearnRW, the first levels of most activities (which include letter or phoneme identification) may appear extremely boring, especially to children at the higher end of the age range covered by iLearnRW (i.e. 11-year-olds). However, to ensure that the software can be used by any student, the default profile assumes that every child struggles with every difficulty. This guarantees that the software is useable in those situations where the screening procedure is not possible. For example, if the software is used after the project has ended, it will still work without the screening information.

3.3. Language areas/difficulties, user profile and activities

The different levels of each language area (i.e. profile entry) also constitute the specific categories of linguistic material that will be used in the activities. A set of nine (9) activities has been designed, each of which addresses a number of language areas and a number of linguistic levels within each language area. Table 6 illustrates the sample activity and the language areas it addresses.

Activity #	Activity	Language areas / Difficulties (EN)	Language areas / Difficulties (GR)
1	Pelmanism	[2] Vowel Sounds [3] Suffixing [4] Prefixing [5] G-P correspondence [6] Letter / word patterns [7] Letter names [8] Irregular / sight words [9] Confusing letter shapes	[2] Phonemes: Consonants [4] Derivational suffixing [5] Inflectional suffixing [6] Prefixing [7] G-P correspondence [9] Word recognition: sight / irregular words [10] Letter visual similarity

Table 6. Language areas addressed by a sample activity (Pelmanism)

Depending on the language areas an activity addresses, it includes a different number of game levels (which correspond to the language areas addressed) and a number of game rounds in each level (which correspond to the specific instances (or linguistic levels) of the language area addressed). Each game round within a game level (e.g. a game level addressing Prefixing) can present content from 1 or more linguistic levels (e.g. prefixed Vs denoting quantity (index 3) and lexical prefixes on ADJs (index 4)). An example is provided in Table 7 below.

	Level 6: Prefixing
Round 1	Index 1: ADJS Privative/Opposite/Difficulty Index 2: ADJs& NOUNs: Quantity
Round 2	Index 3: Vs: Quantity Index 4: Lexical prefixes on ADJs
Round 3	Index 5: Prefixed Vs Index 6: Lexical prefixes on Vs

Table 7. Example of a game level structure

The different game levels of the activities are of increasing linguistic complexity (i.e. from phoneme/letter level to word or phrase level) but can be played independently, depending on the language area that is most problematic for a specific child. A table with information on the language areas covered by each activity is provided in **Appendix B**. Note that the exact nature of the levels and rounds for each learning activity has yet to be determined.

Upon completion of the initial screening, the child has been assigned a severity score on each language area, which provides an indication of the severity of the difficulty associated with this language area. This information is used to determine the following:
- which activities will be suggested for the child,
- which game levels of these activities will be presented.

Each game level draws teaching material (i.e. letters, words, syllables, etc.) from the iLearnRW database depending on the linguistic level(s) (index) of the area each particular game round is associated with. So, Round 1 of the hypothetical activity in Table 7 will draw prefixed adjectives

beginning with *α-*, *αντι-* and *δυσ-* (index 1) as well as prefixed adjectives and nouns beginning with *υπερ-*, *υπο-* and *κατα-* (index 2) from the iLearnRW database.

When a child begins playing an activity, the game level he/she will begin with will be determined by the most severe language difficulties he/she faces, that is, the language areas whereby he/she has been assigned a high severity score during screening. By default, all language areas (and therefore all game levels) will be presented to a child unless the screening has indicated that he/she faces no problems in an area (i.e. he has gained a very high index in the scale).

By playing a given activity, the child's performance will update the user profile by assigning an index to him/her, i.e. placing him/her on a given linguistic level of the language areas (game levels) played and which will indicate the instances of the language area/difficulty that still pose considerable difficulties for him/her (i.e. those that are in higher levels than the index) as well as those that he/she is handling at a satisfactory level at the time (i.e. those that are in lower levels than the index). In order to be assigned an index on a language area, the child has to exhibit the following performance:

Language area X	Success score (%)
Always struggles with the language area	< 65%
Sometimes struggles with the language area	65% - 80%
Doesn't struggle with the language area	>80%

Table 8 Performance leading to placement on a specific index

Using the language area of Prefixing as an example, a child will be assigned an index of 3 if he/she marks a success score above 65% in activities containing verbs with a prefix denoting quantity (index 2) and above 65% in examples containing adjectives denoting privative/opposite meaning (index 1). The following table illustrates an example of a child's performance on a game level of a hypothetical activity, leading to his placement in linguistic level 3 (assignment of index 3) on the language area Prefixing.

	Index					
	1	**2**	**3**	**4**	**5**	**6**
Prefixing	**ADJS:** Privative/ Opposite/ Difficulty: α-, αντι, δυσ-	**ADJS& NOUNS:** Quantity (over/under): υπερ-/υπο-, κατα-	**VERBS:** Quantity (over/under):	**Lexical prefixes:** δι-/τρι-, πρωτο-, αυτο-, πολυ-, μικρο-, ψιλο-, ημι-	**VERBS:** ανα-, αντι-, απο-, δια-, εισ-, εκ-/εξ-, εν-, επι-, κατα-, μετα-, παρα-, περι-, προ-, προσ-, συν-	**VERBS:** Lexical prefixes: ψιλο-, μισο-, κουτσο-, ψευτο-
Performance	93%	81%	64%	52%	45%	51%

Table 9 Level placement and index assignment based on performance in screening

However clear-cut the above scheme might be, it is still very possible that the child's performance marks lower scores than expected in one or more of the low linguistic levels (or higher scores in one or more of the high levels) and thus may not clearly indicate the linguistic level on which he/she should be placed on. In this case, he/she is still assigned an index based on the above criteria but the still-problematic areas are also marked in his profile and feed relevant materials to the activities.

3.4. Activities and teaching strategies

All iLearnRW activities were designed to integrate a combination of teaching approaches that have been found to be most effective for students with dyslexia. Based on the teaching strategies employed in iLearnRW, as these were described in D3.2, the software is being designed in such a way that a predefined set of language areas are targeted, emphasizing two critical educational strategies: (a) use of a multi-sensory approach to learning by employing a variety of stimulus types, i.e. visual (a wide range of colours and shapes), auditory and tactile (through enhancing visual-motor coordination), and (b) enhancing metacognitive and metalinguistic awareness by adopting a top-down, explicit teaching of linguistic relations and phenomena. At the same time, however, the approach adopted by iLearnRW is communicative and learner-centred, in the sense that teaching material is first implicitly presented through engaging and motivating game scenarios presented in instructional animated videos, while target forms are initially presented and linguistic phenomena are explicitly presented upon failed attempts as feedback. Explicit presentation of the linguistic relation (rule or phenomenon) in question is continuously provided to the learner as feedback to all failed attempts.

The main educational aims of the activities included in the iLearnRW bank involve:
- Discrimination of different shapes and sizes,
- Discrimination of subtle phonetic distinctions,
- Processing shape orientation (e.g. discriminating d from b, 3 from ε),
- Using and enhancing both central and peripheral vision,
- Using, combining and enhancing auditory and visual modalities,
- Coordinating visual with motor skills,
- Reflect on own performance and enhance metacognitive and metalinguistic awareness.

A detailed description of each activity is provided in **Appendix B**

4. System Specifications

No update of the system specifications was required. The system specifications, as described in Deliverable D3.3, remain valid.

Appendix A. LOW PRIORITY FEATURES OF READER-MODE

A.1. **Assistive Features of Reader**

There are two assistive features we have considered which are of low priority and thus presented in this Appendix; the chunking mode and the text information screen.

A.1.1.   Chunking mode

The chunking mode allows the user to set amount of text displayed on the page and additionally to launch auto scroll to help practice information processing and pacing. Auto scroll automatically progresses the reader through the text. This feature is useful as it prevents a reader from being overwhelmed by the amount of text on the screen at any one time.

Such a feature contains many options for controlling the amount of text displayed, launching autoscroll and setting autoscroll playback speed. The main settings are:

'Chunks to show' allows the user to set the display of text by the amount of text displayed. By default an entire page is shown. Alternatives include showing the text by paragraph, by sentence and by word.
 The 'Auto scroll' feature also contains the option of controlling the playback speed.

Figure 9 shows what the chunking feature may look like.

Logic will be required to calculate segment boundaries. This may be more challenging with sentence boundaries, particularly in the presence of names with initials and acronyms containing full stops. There will also be some challenge in determining when a single word or multiple words should be displayed in the word chunks display.
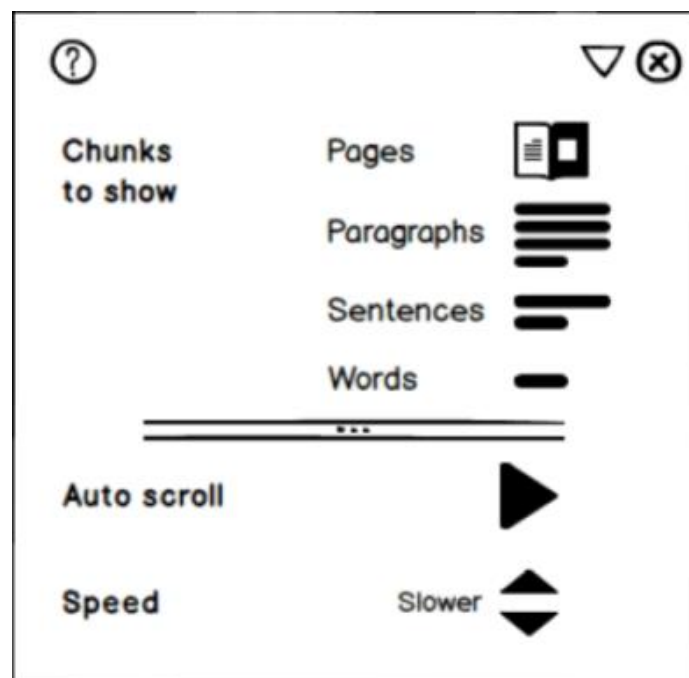
Figure 9. Chunking Feature

A.1.2. Text information screen

The text information screen displays the key information about the text to the user. It is in many ways similar to the pre-reading information screen but the nature of the information is at a high level.
The screen is divided into three types of information:

    Basic info containing metadata about the text
    Readability indicating level of difficulty with respect to established readability measures as well as the profile
    Text metrics providing information about numbers of words, sentences, paragraphs, etc.

Figure 10 shows what the text information screen may look as in Figure 10.
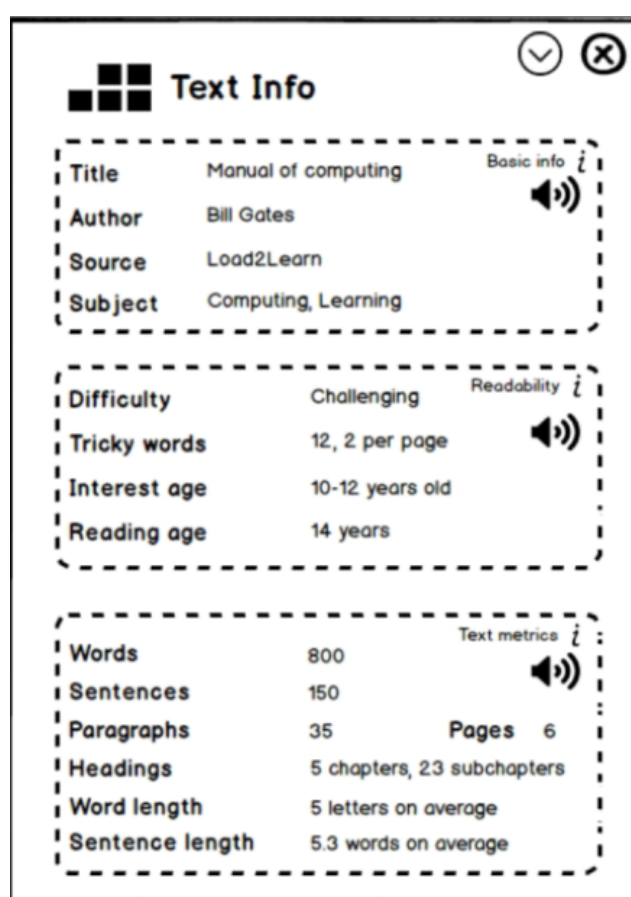
Figure 10. Text Information Feature

A.2. **Reader Features**

All of the reader features in Table 3 were marked as being low priority. They are all presented in this appendix.

A.2.1.   **Main 'Library' screen**

The Library is used as the access point for opening a book. In addition to listing all the books currently stored on the tablet, it contains a sorting mechanism to display this list according to the book title, the book author, the readability of the book and the date the book was added. This screen may look something like Figure 11.
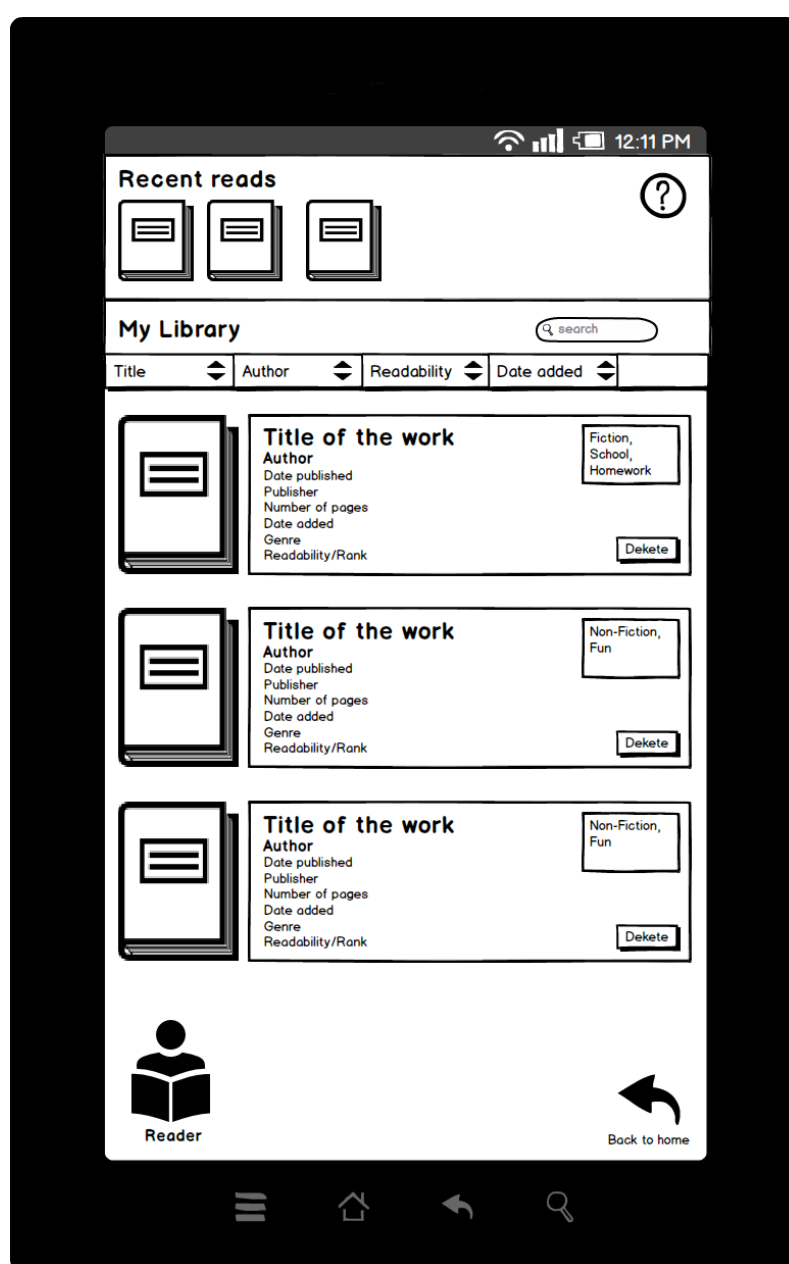
Figure 11. Library

A.2.2. Table of contents screen

A table of contents can provide important information to a struggling reader about both the structure of the text and its overall meaning. Getting a reader to create their own outline is considered to be an important comprehension activities.

This feature would by default display a given book's table of contents if such information was available. A reader would also be able to edit this information or create their own personal table of contents, associating it with the given book.

In addition to displaying the information, selecting a heading title would navigate to the appropriate section in the text. The table of contents screen could possible look like Figure 12.
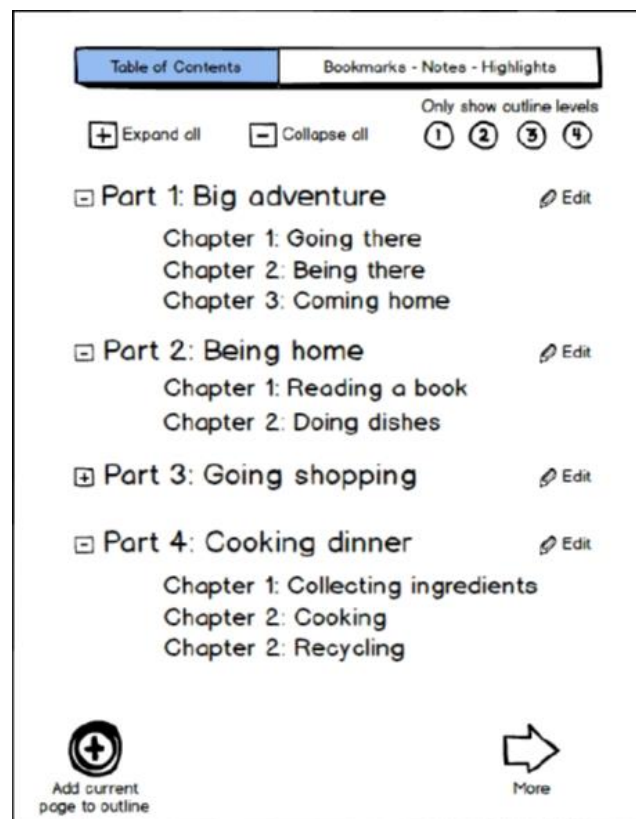
Figure 12. Table of Contents Feature

A.2.3. Bookmark / Notes / Highlights screen

This screen allows the user to access their annotations on the text. Any Bookmark, Note or Highlight created is listed on this screen. Each annotation can be edited, removed or added to the text outline. The annotations are displayed in the order they appear in the text and they can be searched. Each annotation can be edited, removed or added to the text outline.

A.2.4.   General settings screen

The General settings screen is a location for setting options left over from other screens. These settings include:

Screen brightness while using the Reader
Lock of screen orientation to landscape or portrait
Set options for turning pages by tapping or swiping
Choice of page turn animation
Choice of icons and/or text for user interface
Voicing of icons on tap
Amount of information shown

The general settings screen could possible look like Figure 13.
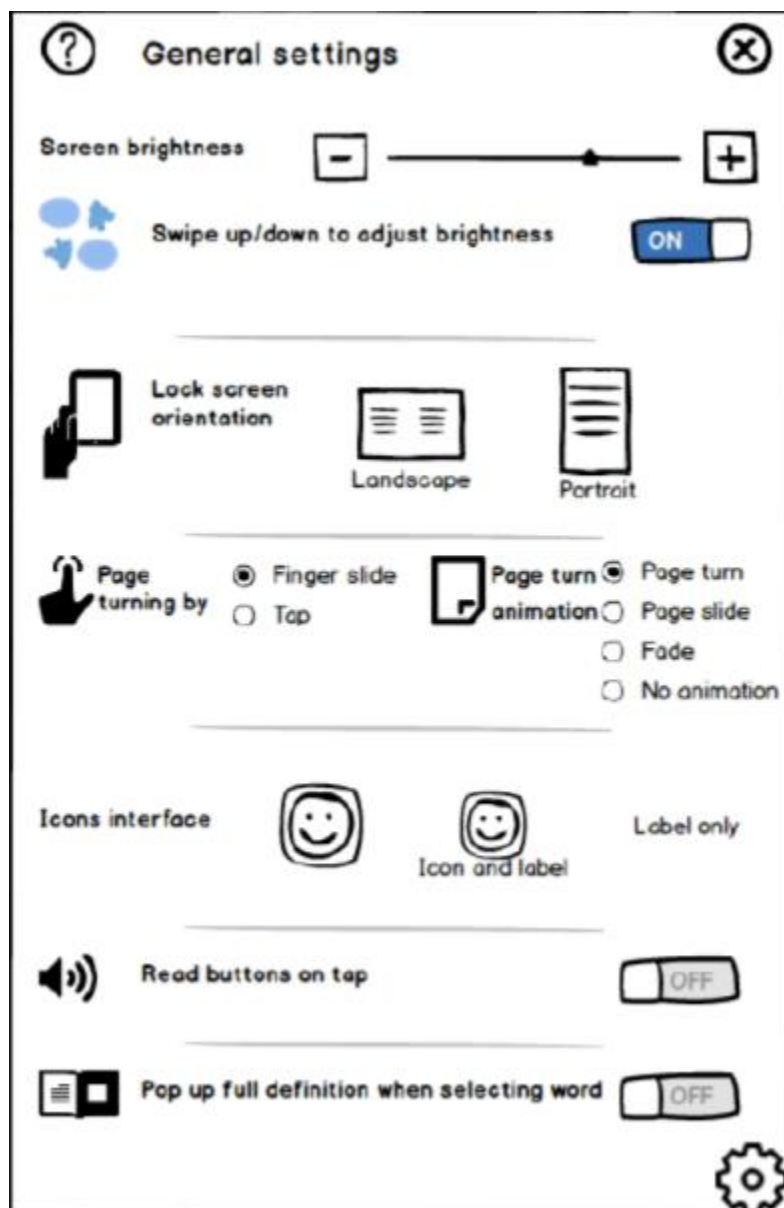
Figure 13. General Settings Feature

A.2.5. User help overlay

The user help overlay is intended to help users familiarize themselves with the interface using as little text as possible. The help is presented in the form of tips overlaying the book with navigation options to move between the tips.
Additionally, users can also choose to have tips read out using Text-to-Speech. They can also choose to have tips shown by default, the next time the reader is launched. The user help overlay could possible look like Figure 14.
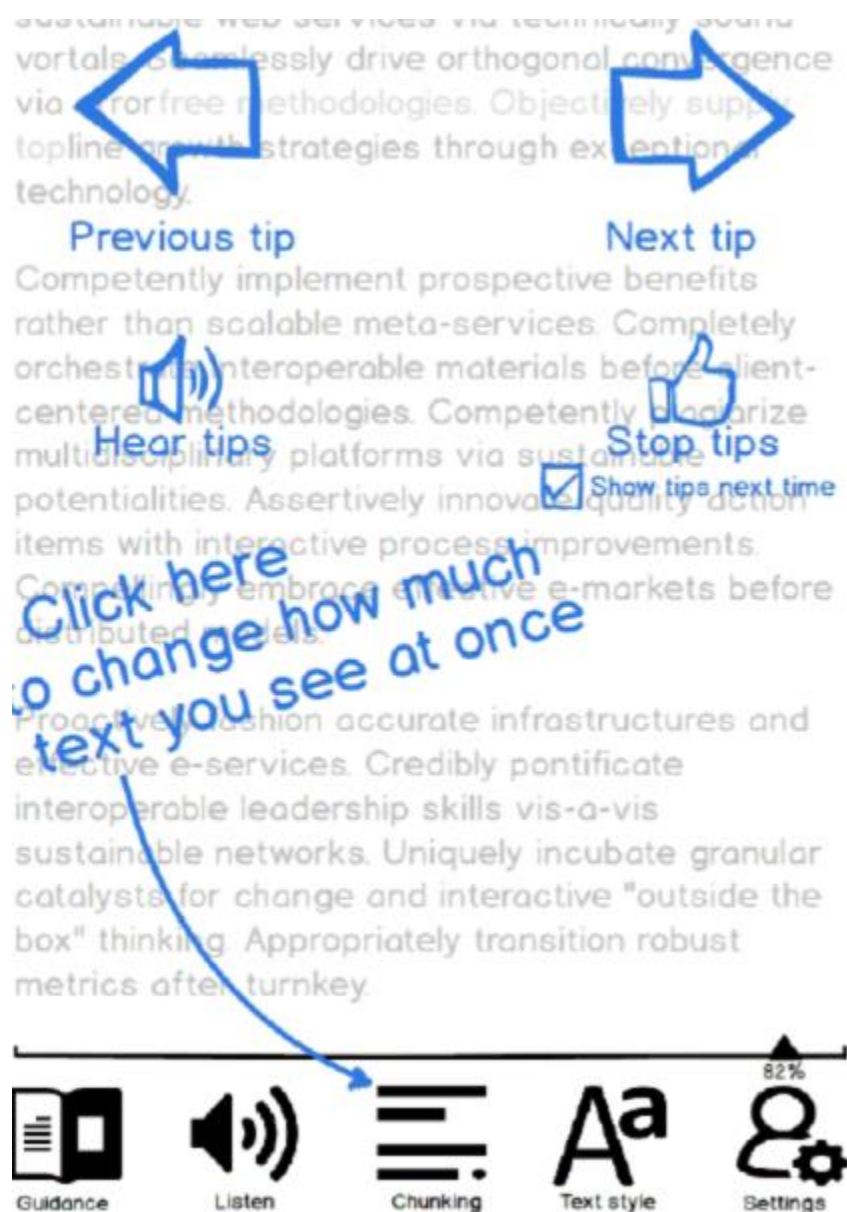
Figure 14. User Help Overlay

Appendix B.   ACTIVITIES EMPLOYED IN LEARNING STRATEGIES

B.1. List of activities and the language areas addressed in each level

		1. Pelmanism	2. WhackaMole	3. Bridge Builder	4. Sorting Potions	5. Fix the Footpath	6. Minefield	7. Curling	8. Typing Train Dispatcher	9. Syllable/Suffix Karate Chop
	ENGLISH									
1	Syllable Division			X	X		X	X	X	X
2	Vowel Sounds	X	X		X		X	X		
3	Suffixing	X	X	X	X	X		X	X	X
4	Prefixing	X	X	X	X	X		X	X	X
5	G-P Correspondence	X	X		X		X		X	
6	Letter / Word Patterns	X	X	X	X		X			
7	Letter Names	X	X		X					
8	Irregular / Sight Words	X	X				X		X	
9	Confusing letter shapes	X	X		X	X	X	X	X	
	GREEK									
1	Syllable Division			X	X		X	X	X	X
2	Phonemes: Consonants	X					X	X		
3	Phonemes: Vowels				X		X	X		
4	Derivational Suffixing	X	X	X	X	X		X	X	X
5	Inflectional Suffixing	X	X	X	X	X		X	X	
6	Prefixing	X			X	X		X	X	X
7	G-P Correspondence	X	X		X		X			
8	Grammar: Function Words				X	X	X		X	
9	Word recognition: Sight / Irregular Words	X	X				X	X	X	
10	Letter Visual Similarity	X	X				X			

B.2. **Description of iLearnRW activities**

Table 10 and Table 11 show the index of the considered language areas for English and Greek, respectively.

[1] Syllable Division
[2] Vowel Sounds
[3] Suffixing
[4] Prefixing
[5] Grapheme/ Phoneme Correspondence
[6] Letter patterns
[7] Letter names
[8] Irregular/sight words
[9] Confusing letter shapes

Table 10. Index of Language areas / Difficulties – English

[1] Syllable Division
[2] Phonemes: Consonants
[3] Phonemes: Vowels
[4] Suffixing: Derivational
[5] Suffixing: Inflectional / Grammatical
[6] Prefixing
[7] Grapheme-Phoneme Correspondence
[8] Grammar: function words
[9] Word recognition: sight / irregular words
[10] Letter visual similarity

Table 11. Index of Language areas / Difficulties – Greek

A detailed description for each activity is given in the following subsections

B.2.1. Pelmanism / Matching game
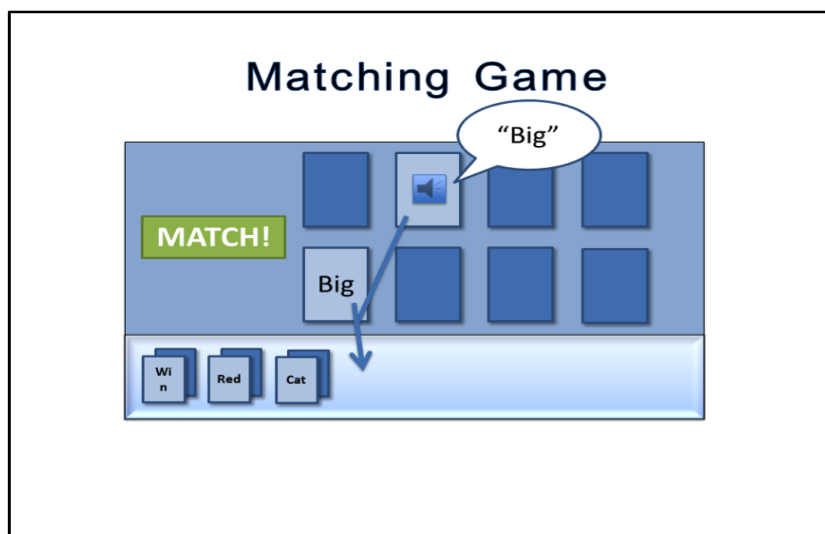
Brief description

The child is presented with a number of cards displayed on the screen in a grid. The child is instructed to tap on one card and then find a matching card in the grid (depending on specified rules). When two cards are matched they move to the bottom of the screen in a match and the child wins a point. The level is completed when all the cards have been matched and the child wins a star. The child also wins one, two or three stars depending on how fast he/she completes each level (three stars are assigned to fastest times, one star to slowest).

Language

English & Greek

Language area/Difficulty

English:
[2] Vowel Sounds
[3] Suffixing
[4] Prefixing
[5] Grapheme-Phoneme correspondence
[6] Letter patterns
[7] Letter names
[8] Irregular/sight words
[9] Confusing letter shapes

Greek:
[2] Phonemes: Consonants
[4] Derivational Suffixing
[5] Inflectional Suffixing
[6] Prefixing
[7] Grapheme-Phoneme correspondence
[9] Word recognition difficulties: sight / irregular words

[10]   Letter (visual) similarity

Educational aspects

Learning outcomes

Identify letter shapes.
Process and establish grapheme-to-phoneme correspondences on a grapheme-phoneme and word level.
Identify word patterns.
Perform word decomposition and identify morphemes (suffixes, prefixes).

Teaching strategies

<u>Multi-sensory (visual, auditory)</u>
Use of images, variable font colours and sizes; visual discrimination of shapes.
<u>Bottom-up teaching approach</u>
Linguistic relations are made explicit in the feedback provided to the child, enhancing metacognitive awareness.

Detailed description

Scenario

The child is presented with the game scenario with a short instructional animation. The animation contains a smaller version of the visual aspect of the game and the child is informed about the aim of the game.
- Cards appear on a two by two grid.
- An animated finger appears that taps on a single card and it turns over to reveal the word "big"
- Then, the finger taps on a second card, which turns over with a sound icon on it and the word "pig" is pronounced.
- The finger taps on the second card again, to indicate that it thinks that the cards match.
- The words "No Match" and an icon with a cross appear to the side of the grid
- The two cards become bigger and the difference is highlighted: the word "big" is presented with a highlighted 'b' and the word "pig" appears on the second card, with a highlighted 'p'. Both words are then pronounced, emphasizing the different phoneme ('b' and 'p').
- The two cards turn back over such that all cards are again face down.
- The "No Match" and cross icon disappear
- The animated finger appears again and taps the "big" card, which turns over to reveal the word "big"
- Then it taps on a different card, which also turns over to reveal the word "dig".
- The finger then taps on an area outside the grid to indicate that it thinks that the words do not match, so the "dig" card turns face down again.
- Then it taps on a different card, which also turns over. This has a "sound" icon on it. The word "big" is spoken.
- The finger taps on the second card again to indicate that it thinks that the cards match.
- The word "Match!" and an icon with a tick appear to the side of the grid.
- The matched cards slide down to the bottom of the screen (see mock-up) into a "matched" area.
- The same animation is repeated for the remaining two cards on the grid so as to complete the level, which rewards the hypothetical player with stars.

After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

Language levels vary on complexity of language. The levels of the activity and the language area addressed by each level is given in Table 12.

(Unique matches are required for cards)

Level	Card 1	Card 2	Language
1	Letter	Same letter (letter name pronounced on match, English version, letter sound pronounced in Greek version)	English / Greek
2	Letter Phoneme	Pronounced word that begins with that letter Written word that begins with that phoneme	English / Greek
3	Written word Pronounced word – Sound (TTS)	Pronounced word Written word	English / Greek
4	Word	Rhyming word (both words pronounced on match)	English
4	Word with suffix X	Different word with same inflectional suffix	Greek
5	Word with suffix X	Different word with same derivational suffix	English / Greek
6	Word with prefix X	Different word with same prefix	English / Greek

Table 12 Structure of game levels

Game play

- A grid of cards appears, probably 2x4 (or 2x6 if the tablet screen is large enough).
- All cards are face down.
- A timer begins. The timer ends when all of the cards have been matched. This time is stored in the logger and is used as an indication of success. It may also be shown to the user during an initial pop-up to highlight how long it took them to play the game the last time they played.
- When the activity is started, an integer is passed in, indicating whether the difficulty being addressed.
- When a user taps on a card, it turns over.
- The content of that card is then presented. If it is visual only, nothing additional happens. If it is auditory, the word is spoken.
- While the word is being spoken, no other card can be turned over.
- If no other card has been turned over then the program waits until the user selects a second card to turn over.
- If two cards are now turned over, the locations are compared to check for a match.
- While the two cards are turned over, no other card may be turned over.
- If the cards match and the user taps on the second card again, the word "Match!" and an icon with a tick or a smiling face appear to the side of the grid.
- The matched cards slide down to the bottom of the screen (see mock-up) into a "matched" area
- The "Match!" and tick icon disappear
- If no other cards are left on the grid, the game is over. If this is the last round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to play the game, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button. If there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to play the round and a "Continue to next round" button

- If the child taps on an area outside the grid, indicating that he/she thinks the two cards do not match, the second card turns over again and the child continues tapping on other cards until he/she finds a match.
- If the cards do not match but the child taps on the second card again (indicating that he/she thinks they match), the words "No Match" and an icon with a cross or a sad face appear to the side of the grid. The two cards then move to the foreground and the difference between them is highlighted (visually, auditorily or both), so that the child clearly understands why the cards do not match.
- Both cards turn back over such that all cards are now face down.
- The "No Match" and cross icon disappear.

Progression rules

The matching rules are indicated at the beginning of each level by a small animation on a 2x2 grid. The difficulty of the game increases as the child progresses from less complex to more complex instances of the language area addressed by each level. Additionally, words presented become less frequent as levels increase and also selection of patterns from higher DILP teaching points (English version, see User Modelling Deliverable).

Depending on the difficulty under consideration, a different number of "rounds" are played. Each round progresses in difficulty independently of how hard the linguistic difficulty is (i.e. the progression for the pattern of 'r' [index 6 in English Profile] gets harder from round to round as will the progression of pattern 'ch' [index 26 in English Profile]).

English version:
Sample rounds for the English version can be seen in Table 13.

Letter Shapes	Irregular Words	Letter Patterns
Letter–to-letter	Word–to–word	Word–to-word
	Word–to-rhyme	Pattern–to–word
	Sound–to-word	Word–to–rhyme
		Sound-to-word

Table 13 Different matches over the different rounds of the game – English version

Each round consists of matching different types of content. The different levels require some slight modifications to the content selection method outlined below:
- For word to rhyme - for both irregular and letter patterns: four words are selected in the same manner as below but each then needs to be checked for an associated random word.
- The set of rhyming words cannot rhyme with each other as otherwise unique matches would not be possible
- For pattern to word – the content selection process is the same but instead of associating the 8 cards to pairs of the four selected words, four of the cards are randomly associated with the pattern and the other four cards are randomly associated with the word
- For sound to word – in this case, the words are allocated in the same way but the four "paired" words are somehow marked as being non-visible and a sound icon instead appears when the card is turned over. This speaks the word associated with that card

Greek version:
Sample rounds for the addressed difficulties are given in Table 14:

	Level 2: Grapheme-Phoneme Correspondence	**Level 5: Prefixing**
Round 1	phoneme-to-written word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: NOUNS&ADJs: Diminutives & Enlargement
Round 2	letter-to-pronounced word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: NOUNS: Profession/person
Round 3	phoneme-to-written word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: NOUNS: place/nstrument/means/container
Round 4	letter-to-pronounced word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: NOUNS: State/property/quality/colour
Round 5	phoneme-to-written word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: NOUNS: Activity/activity outcome
Round 6	letter-to-pronounced word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: ADJs
Round 7	phoneme-to-written word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: VERBs
Round 8	letter-to-pronounced word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	word-to-word: Der.suffixes: VERBs&ADJs lexical suffixes

Table 14 Linguistic material covered in each round – Greek version

In order to progress from one round to the next, the child has to achieve a specified success level. This is defined as a minimum number of failed matches and a maximum time taken to complete each round. For example, in order for the child to progress from Round 12 to Round 13 in Level 6 (Greek version), he/she has to have failed in fewer than 20% of the attempts he/she made in the specific round. If he failed in more than 20% of his/her attempts, the next round contains more examples of the same category (i.e. word-to-word: infl. suffixes: freq. noun classes (gen.sing&pl)). However, the progression scores will be finalised after the final design of the game has been set.

Language materials

English:
List of confusing letter shapes (e.g. b/d, j/g, m/n)
List of words annotated as sight reading
Words linked with corresponding rhyming words (has to be through database link otherwise no frequency annotation)
Words annotated by frequency
Words by pattern (pattern from DILP)
Patterns by teaching point

Greek:
Letters
Phonemes
Grapheme-phoneme pairs
Word patterns
Suffixes
Prefixes

B.2.2. Whackamole
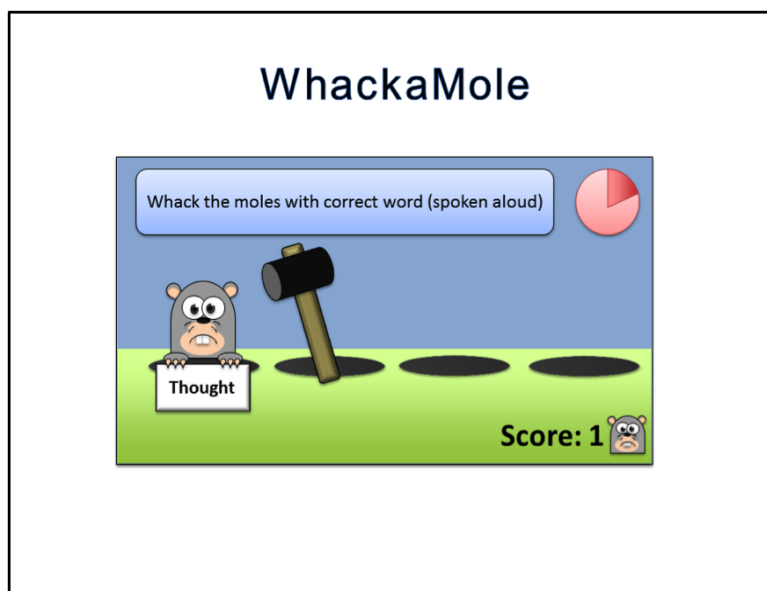
Brief description

A pattern is presented on a prompt card (e.g. sound, letter, word or picture) and several moles pop up holding cards with letters or words either matching the pattern or not matching the pattern. Player has to hit the mole matching the pattern and not a mole not matching the pattern.

Language

English & Greek

Language area/Difficulty:

English:
[2] Vowel Sounds
[3] Suffixing
[4] Prefixing
[5] Grapheme-phoneme correspondence
[6] Letter patterns
[7] Letter names
[8] Irregular/sight words
[9] Confusing letter shapes

Greek:
[4] Derivational suffixing
[5] Inflectional suffixing
[7] Grapheme-phoneme correspondence
[9] Word recognition difficulties: Irregular/sight words
[10]   Letter visual similarity

Educational information

Learning outcomes

Identify letter shapes.
Establish and enhance grapheme-to-phoneme correspondences on a grapheme-phoneme and word level.
Identify and match word patterns.
Discriminate letters that look similar.
Perform word decomposition and identify morphemes (suffixes, prefixes).

Teaching strategies

Multi-sensory (visual, auditory)
Use of images, variable font colour and size; visual discrimination of shapes.
Bottom-up teaching approach
Linguistic relations are made explicit in the feedback provided to the child, enhancing metacognitive awareness.

Detailed description

Scenario

The player is presented with a field with molehills on it. The task is to clear the field of all molehills (so that the character can get a across). When the player taps on the correct mole, the mole goes into the hole and pulls all of the molehill behind him. When the player hits the incorrect mole, the mole jumps out of the hole and digs another hole thus creating a new molehill. The game ends when the player has cleared all the molehills.

When opening the application, the first thing to appear is an instructional animation.
- Mole holes appear in a row of four as in the picture above.
- A hammer also appears.
- The instructions state "whack the mole holding the words ending in "ing" and a prompt card containing the suffix 'ing' appears.
- The score is set at 0.
- A mole pops up out of hole 1 holding the word "acting".
- A finger appears and taps on the mole, so the hammer hits the mole and the mole becomes dazed.
- The sign is dropped and falls to the bottom of the screen.
- The score becomes 1.
- A second mole pops up out of hole 3 holding the word "worked".
- The finger appears again and taps on the mole, so the hammer hits it.
- A pop-up appears saying "Wrong mole!", while the word 'worked' brought to the foreground and the suffix 'ed' is highlighted and compared with 'ing', to show the child that they are not the same.
- The score becomes 0 again.
- After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity
-

- This game could be seen as an easier variant of pelmanism because it doesn't engage memory

Levels

Language levels vary on complexity of language as in Pelmanism.
Skill levels within language levels increase by speed of moles appearing or the number of distractor moles appearing. Table 26 illustrates the structure of the game levels.

Level	Prompt card	Card held by mole	Language
1	Letter	Same letter, visual or auditory	English / Greek
2	Letter	Pronounced word that begins with that letter (or includes that letter in higher rounds)	English / Greek
	Phoneme	Written word that begins with that phoneme (or includes that phoneme in higher rounds)	English / Greek
3	Word Pattern	Word containing the pattern pronounced on match (English version)	English
4	Pronounced word – Sound (TTS)	Written word	English / Greek
5	Word	Rhyming word (both words pronounced on match)	English / Greek
6	Word with prefix X	Different word with same prefix	English / Greek
7	Word with suffix X	Different word with same suffix	English / Greek

Table 15. Structure of game levels

Game play

- Four mole hills appear.
- A hammer appears and will move to wherever the player taps on the screen
- Oral instructions are played explaining which moles need to be whacked. These instructions are more extended than the visual instructions also displayed. The play button on the instruction bar will replay these speech instructions.
- When the activity is started, an integer is passed in, indicating the difficulty being addressed.
- Each piece of content used must be tagged as either being "target" or "not target".
- Like in Pelmanism, each level consists of a number of rounds of increasing difficulty. Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- Moles appear randomly holding either correct or incorrect words/letters. The appearance is animated with the mole rising up from inside the mole hole.
- The child has to tap on a mole so that it is hit with the hammer.
- Depending on the round, multiple moles can be on the screen at any one time.
- When multiple moles are visible only one mole shows the correct answer at any one time.
- If a mole is not hit, after the length of time each mole is meant to be on screen (see table 3) it slides back into the mole hole it came out of.
- If a mole is hit and is holding a "correct" word:
- The mole becomes dazed and drops the word it is holding
- The word is pronounced and then falls to the bottom of the screen
- The score is increased by one.
- If a non-target mole (one that is holding a non-matching word) is hit:
- If this is not the last mole in the round,

- A pop-up appears saying "Oops! Try again"
- The non-matching word is then brought to the foreground and the difference with the prompt is highlighted (either in font colour, font size, sound or picture).
- The score is decreased by one.

When the last mole in the last round is hit, after the appropriate feedback is given, a pop-up screen appears with a highlight of the difficulty being addressed, the number of moles correctly hit (e.g. 14/30), a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.

If this is the last mole but there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of moles correctly hit out of the total number of correct moles that popped up (e.g. 8/10) and a "Continue to next round" button.

Progression rules

Within each level, each round targets different instances of each language area and vary in difficulty based on the number of moles within the round. The number of moles for each round is shown in Table 16.

Round Number	Total number of words	Number of correct words	Number of incorrect words
1	6	5	15
2	30	10	20
3	40	15	25

Table 16. Number of words needed for each round

A sample of the linguistic aspects covered in each round is provided in Table 17.

	Level 1: Letter similarity	Level 2: Grapheme-to-phoneme correspondence
Round 1	letter-to-letter: α/o, ψ/ω	phoneme-to-written word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...
Round 2	letter-to-letter: η/μ, π/τ	letter-to-pronounced word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...
Round 3	letter-to-letter: 3/ε/ξ, φ/β/θ	phoneme-to-written word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...
Round 4	letter-to-letter: κ/χ/γ/λ, δ/ρ/σ/β	letter-to-pronounced word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...
Round 5	letter-to-word: α/o, ψ/ω, η/μ, π/τ	phoneme-to-written word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...
Round 6	letter-to-word: 3/ε/ξ, φ/β/θ, κ/χ/γ/λ, δ/ρ/σ/β	letter-to-pronounced word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...
Round 7		phoneme-to-written word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...
Round 8		letter-to-pronounced word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...
Round 9		letter-to-pronounced word: ευ:/ev-ef/, αυ:/av-af/
Round 10		letter-to-pronounced word: εϋ: /eɪ/, οϋ: /oɪ/, αϊ: /aɪ/
Round 11		letter-to-pronounced word: οΰ: /oi/, αΐ: /ai/

Table 17. Language covered in each round

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum number of failed hits in each round. For example, in order for the child to progress from Round 2 to Round 3 in Level 1 (Greek version), he/she has to have hit the correct mole in more than 80% of the total number of moles in the specific round. If his/her failed hits are more than 20%, the next round contains more examples of the same category (i.e. letters '3/ε/ξ' and 'φ/β/θ').

Language materials

English:
List of confusing letter shapes (e.g. b/d, j/g, m/n)
List of words annotated as sight reading
Words linked with corresponding rhyming words (has to be through database link otherwise no frequency annotation)
Words annotated by frequency
Words by pattern (pattern from DILP)
Patterns by teaching point

Greek:
Letters
Phonemes
Grapheme-phoneme pairs
Sight and irregular words
Semantically related word pairs
Suffixes
Prefixes

B.2.3. Bridge Builder
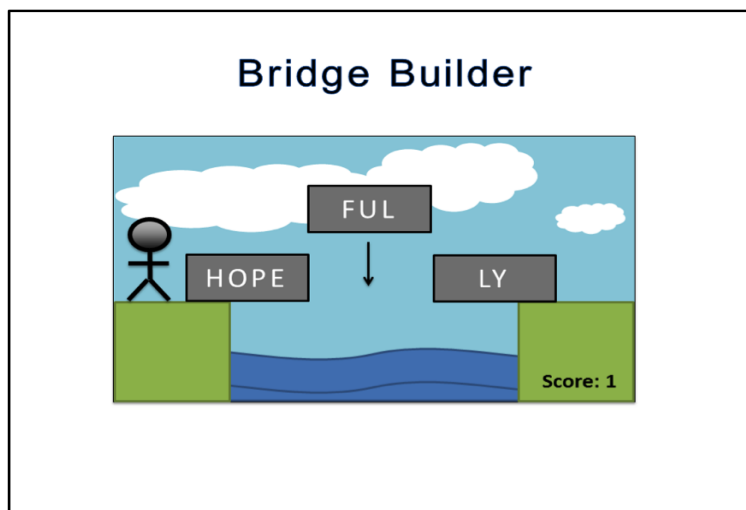
Brief description

The child is presented with a landscape he/she needs to cross with canyons or rivers presenting obstacles. Player clicks on the first obstacle (e.g. river or a canyon) that she needs to cross and is presented with a picture of the obstacle and blocks with words, word segments or letter patterns that the player needs to assemble into a bridge.

Language

English & Greek

Language area/Difficulty:

English:
[1] Syllable division
[3] Suffixing
[4] Prefixing
[6] Letter patterns

Greek:
[1] Syllable division
[4] Derivational suffixing
[5] Inflectional suffixing
[6] Prefixing

Educational information

Learning outcomes

Compose words from letters or syllables.
Compose words from their constituents (syllables or morphemes).
Identify common suffixes / prefixes automatically and use them to create words.

Teaching strategies

Multi-sensory approach:
Use of images, variable font colour and size; visual discrimination of shapes; visual-motor coordination.

Bottom-up teaching approach:
Language relations are made explicit through feedback.

Enhancement of meta-cognitive awareness:
The child is asked to self-reflect, judge his own response and is explicitly explained his errors.

Detailed description

Scenario

When opening the application, the child is introduced to the scenario of the game with an instructional animation.
A map appears, with a knight at the bottom left of the screen and a number of landscapes marked across a route that he has to follow to reach a castle and kill a monster. The route he has to follow is marked with a dashed line.
- An animated finger taps on the first landscape and the knight moves there.
- The screen changes and the knight appears on one bank of a river, waiting to cross the river.
- A series of building blocks are in a random order across the bottom of the screen.
- There are three blocks containing "ful", "ly" and "hope".
- Across the gap, over the river, there are three dashed outlines of where the blocks can be dropped.
- The instructions state "The knight needs to cross the river. Build a bridge form these blocks" both visually and in sound.
- The score is set at 0.
- An animated finger appears and taps on the "ful" block, picking it up and moving it into the first position. The "ly" block is then moved into the second position and then the "hope" block is moved into the third position.
- Because the bricks were not placed in the correct order, they don't stick with each other and the bridge is not built. The formed word is brought to the foreground and a question is pronounced (i.e. "is fullyhope a real word?") with a 'yes' and 'no' options next to it.
- If the child responds 'yes', the phrase "no, it isn't a real word" is pronounced. If the/she responds 'no', the phrase "that's right, it isn't a real word" is pronounced.
- Score is decreased to -1
- Then, the animation shows the finger pick up the bricks and put them in the correct positions, forming the word "hopefully".
- The knight begins to cross the bridge and gets to the other side.
- The character pronounces the correct word happily and performs a celebratory dance, while the score is increased to 0.

- The screen scrolls left, revealing the landscape the knight needs to cross.
- The blocks now contain the characters "ac", "ci" and "dent"
- After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Simple version

The bridge is a single line (i.e. one plank to place across a gap). In the initial stages, there may only be pre-assembled bridges to which the player needs to fill gaps.

Complex version

The bridge a multilayered structure to demonstrate better understanding of compositionality. E.g. you need to place blocks with letters 'c' 'a' 't' on the ground and then put a block with the word 'cat' on top of them.

Levels

The game ends when the player has crossed the entire landscape. Language difficulty increases across different levels based on the language area addressed.

Level	Bricks	Language
1	Letters	English / Greek
2	Syllables	English / Greek
3	Prefix + root	English / Greek
4	Stem + suffix	English
4	Stem + derivational suffix	Greek
4	Stem + inflectional suffix	Greek

Table 18 Structure of each level

Game play

- The map appears again and the child has to tap on the second landscape.
- A river and set of blocks appear as above.
- Over the river, a series of dashed boxes highlight where the blocks need to be placed
- Oral instructions are played explaining that the blocks need to be put together to make a word to allow the knight to cross a series of rivers or other obstacles. These instructions match the visual instructions also displayed. The play button on the instruction bar will replay these speech instructions.
- When the activity is started, an integer is passed in, indicating the language area being addressed.
- Based on the language area, content is selected from the software database.
- Each level of the game consists of a number of "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- Each round contains a different background image – green hills, mountain snow and a sunny beach.

The levels of the game vary in difficulty based on the rounds (number of crossings) within the level. The number of rivers for each level is shown in Table 19 and Table 20.

Each round also varies in difficulty based on the content shown on each block (as seen in Table 19)

Level	Number of Rounds (crossings/words)	Content on each block
1	5	Letters
2	10	Syllables
3	15	Prefix + stem
4	25	Stem + suffix

Table 19 Properties of each level – English version

Level	Number of Rounds (crossings/words)	Content on each block
1	5	Letters
2	10	Syllables
3	15	Prefix + word
4	13	Stem + infl. suffix
	17	Stem + der. suffix

Table 20 Properties of each level – Greek version

- The child is required to tap on each building block and drag it into a position on the bridge.
- When a block is moved within the constraints of a dashed box, it "clicks into place" within that box.
- If all of the blocks are placed in the correct order, a stone bridge is build on top of them and the borders of the blocks disappear, showing the word as a whole.
- The knight crosses the bridge, pronounces the word and performs a celebratory dance.
- The score is increased by 1
- If this was not the last river within the level, the screen scrolls left, revealing the next river the character needs to cross.
- If the blocks are placed in an incorrect order, the formed word is pronounced, saying "xx is not a real word!".
- The child gets one more chance to form the correct word, by moving the blocks. If the second attempt is also incorrect, the formed word is pronounced as above and the blocks move automatically into the correct positions, showing the child the correct word, which is pronounced.
- The score is then decreased by 1.
- If the child succeeds in his/her second attempt, the score increases by half a point.
- When the last river in the last round is crossed, after the appropriate feedback is given, a pop-up screen appears with a highlight of the difficulty being addressed, the number of rivers correctly crossed (e.g. 14/30), a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "move to next level" button, which leads to the map screen and lets the child tap on the next landscape.
- If this is the last river but there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of rivers correctly crossed (e.g. 8/10) and a "Continue to next round" button.

- When the child crosses all landscapes, the knight gets to the castle and kills the monster, bringing the game to an end.

Progression rules

Within each level, each round targets different aspects of each language area and vary in difficulty based on the complexity of the linguistic material used. In higher rounds of each level, there are more blocks available that the ones needed for the bridge.

A sample of the linguistic aspects covered in each round is provided in Table 21.

	Level 2: Syllables	Level 3: Prefix + word
Round 1	3-syllable words containing: cv-cv, cv-v, v-cv, cv-vc	ADJS: Privative/Opposite/Difficulty: α-,αντι-,δυσ-
Round 2	3-syllable words containing: cvc-cv(c), vc-cv(c)	ADJS&NOUNS:Quantity (over/under): υπερ-/υπο-, κατα-
Round 3	3-syllable words containing: cv-ccv(c), ccv-cv(c)	VERBS: Quantity(over/under)
Round 4	3-syllable words containing: ccvc-cv(c), cv-cccv(c),	Lexical prefixes: δι-/τρι-,πρωτο-,αυτο-,πολυ-,μικρο, ψιλο-,ημι-
Round 5	3-syllable words containing: v-cccv(c)	VERBS: ανα-,αντι-,απο-,δια-,εισ-,εκ-/εξ-,εν-,επι, κατα-,μετα-,παρα-,περι-,προ-,προσ-,συν-
Round 6	4-syllable words containing: cv-cv, cv-v, v-cv, cv-vc	VERBS: Lexical prefixes: ψιλο-,μισο-,κουτσο-,ψευτο-
Round 7	4-syllable words containing: cvc-cv(c), vc-cv(c)	
Round 8	4-syllable words containing: cv-ccv(c), ccv-cv(c)	
Round 9	4-syllable words containing: ccvc-cv(c), cv-cccv(c),	
Round 10	4-syllable words containing: v-cccv(c)	

Table 21 Language covered by each round – Greek version

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum number of failed attempts in each round. For example, in order for the child to progress from Round 2 to Round 3 in Level 3 (Greek version), he/she has to have formed the correct in more than 80% of the total number of attempts in the specific round. If his/her failed hits are more than 20%, the next round contains more examples of the same category (i.e. ADJS&NOUNS:Quantity (over/under): υπερ-/υπο-, κατα-).

Language materials

Words
Syllable structures
Suffixes
Letter patterns
Words tagged with their morphological structure

B.2.4. Sorting potions
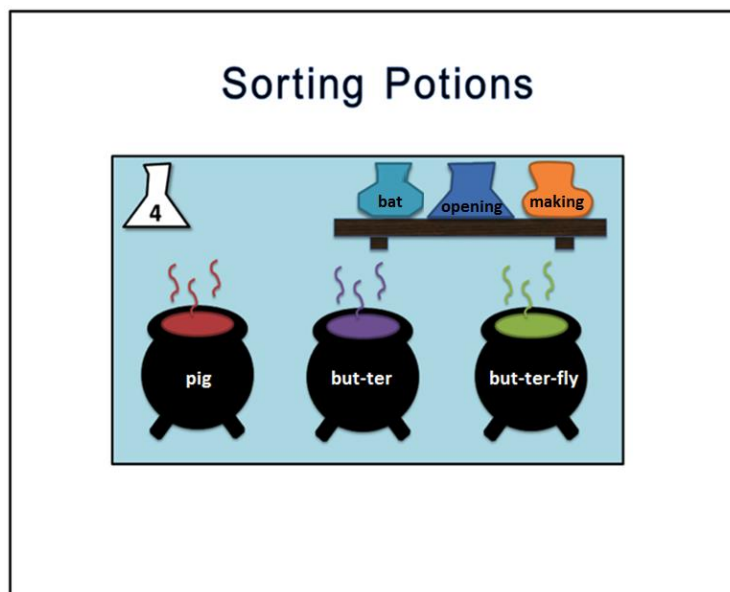
Brief description

The aim of the game is to help a young wizard cross a number of doors guarded by monsters inside a castle. In order to pass through each door, the wizard needs to prepare a potion to put the monster to sleep. The potion needs to be prepared in several cauldrons, each representing a category (e.g. words with long vowels or words with 2 syllables). The player needs to take the appropriate words (out of a pile or out of a text) and put them into right cauldrons. When he is ready, the wizard pours all the cauldrons together into a bowl and presents the potion to the monster. If the recipe is the right one, the monster goes to sleep and the wizard passes through the door and on to the next one. If the recipe is wrong, the monster drinks it and becomes stronger by growing another head. The wizard has to try again.

The difficulty of the game can be increased by requiring a time for each cauldron. There could also be a required minimum. E.g. the player is required to put all words from a text matching a category into the cauldron, or at least 5.

Language difficulty is increased by presenting more options to choose from and more distractors.

Language

English & Greek

Language area/Difficulty

English:
[1] Syllable division
[2] Vowel Sounds
[5] Grapheme-phoneme correspondence
[3] Suffixing
[4] Prefixing
[6] Letter patterns
[7] Letter names

[9] Confusing letter shapes

Greek:
[1] Syllable division
[3] Phonemes: Vowels
[7] Grapheme-phoneme correspondence
[4] Derivational suffixing
[5] Inflectional suffixing
[6] Prefixing
[8] Grammar: Function words

Educational information

Learning outcomes

Syllabify
Identify similar letter shapes and patterns
Identify phonetic similarities (long vowels, consonant clusters)
Identify common phonetic patterns in written words
Identify common morphemes (prefixes and suffixes) in different words
Classify words grammatically (Greek)

Teaching strategies

Multi-sensory approach:
Use of images, variable font colour and size; visual discrimination of shapes; visual-motor coordination.

Bottom-up teaching approach:
Language relations are made explicit through feedback.

Detailed description

Scenario

When opening the application, the first thing to appear is an instructional animated video that introduces the child to the scenario. An evil wizard kidnaps a beautiful girl and imprisons her in his castle. A young, good wizard enters the castle to save the girl, but he has to go through a number of doors guarded by monsters. He prepares potions to either put the monsters to sleep or kill them so that he can cross all the doors and reach the princess.

A series of cauldrons sit along the bottom of the screen, each marking an example word on it, in such a way that the classification rule (e.g. number of syllables) is made clear: "pig", "but-ter", "but-ter-fly".

- "Ingredient" words are set out on a shelf, namely bottles holding "bat", "making" and "opening".
- An animated finger taps on the "bat" bottle and drags it the cauldron marked with "but-ter-fly".
- Red bubbles run across the top of the cauldron
- A pop-up appears stating "Wrong ingredient! Be careful or the potion will not work"

- The score is decreased by one.
- The finger taps on the "bat" bottle again and moves it into the "big" cauldron.
- Green bubbles run across the top of the cauldron.
- A pop-up appears stating "Correct ingredient! The potion is nearly ready…"
- The "bat" bottle is replaced by a bottle of "time"
- The score is increased by one.
- After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

The game is completed after a number of levels, which cover language content of increasing difficulty:

Level	Categories on cauldrons	Language
1	Letter patterns	English / Greek
2	Phonemes	English / Greek
3	N of Syllables	English / Greek
4	Words with prefixes	English / Greek
5	Words with suffixes	English
6	Words of different grammatical categories	Greek

Table 22 Structure of each level

Game play

The game starts and the wizard faces a closed door, with a monster in front of it. The animation shows the wizard start preparing the potion.

- A shelf containing 3 bottles appears alongside three cauldrons at the bottom of the screen.
- Voice instructions are played explaining that the bottles on the shelf need to be placed into the correct cauldrons to make a potion. These instructions match the visual instructions also displayed on the screen. The play button on the instruction bar will replay these speech instructions.
- When the activity is started, an integer is passed in, indicating whether the language area being addressed.
- The game ends in 5 levels, each addressing a different category.
- Each level consists of a different number of "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- The rounds vary in difficulty based on the number of potions that need to be sorted as shown in Table 23.
- Each round also varies in difficulty based on the content shown on each bottle (as seen in Table 23).

Level	Number of rounds/doors to open	Number of bottles/words	Categories on cauldrons	Content on each bottle
1	8	10	words containing letter patterns	written words
2	11	16	words containing certain phonemes (played in sound)	words containing certain phonemes (written)
3	10	20	words with 1, 2 and 3 syllables	words with 1, 2 and 3 syllables
4	6	25	words with prefixes	words with prefixes
5	10	25	words with derivational suffixes	words with derivational suffixes
5	10	25	words with inflectional suffixes	words with inflectional suffixes
6	10	15	words of different grammatical categories (Nouns, Adjectives, Articles etc.)	words of different grammatical categories (Nouns, Adjectives, Articles etc.)

Table 23 Properties of each level – Greek version

- The only game-action a player can make is to select a bottle.
- The other two actions are to listen to the instructions again and to play the sound element on cauldrons.
- A number under each cauldron indicates how many potion bottles are required for the potion.
- When a potion bottle is tapped on, it follows the players' finger around the screen.
- When a potion bottle is dragged on top of the correct cauldron, it falls inside.
- It the word on the bottle is correct (i.e. belongs to the category indicated by the cauldron), green bubbles run across the top of the cauldron, a pop-up appears stating "Correct ingredient! The potion is nearly ready…" and the number under the cauldron is reduced by one.
- If there are more words to process, the bottle is replaced by a new potion bottle appearing on the shelf.
- If the incorrect bottle is dropped inside a cauldron, red bubbles run across the top of the cauldron, a pop-up appears stating "Wrong ingredient! Be careful or the potion will not work".
- The word in the wrong bottle is then shown, indicating clearly why it was incorrect.
- When the last bottle is poured into a cauldron, the cauldrons empty their content in a larger cauldron and the potion is prepared. The potion is then given to the monster, who falls asleep and the wizard goes through the door.
- When the last round of a level is completed, after the appropriate feedback is given, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to process all the bottles, how many bottles were dealt with correctly, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.
- If this is the last bottle but there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to complete this round, the number of bottles correctly placed and a "Continue to next round" button.

Progression rules

Within each level, each round targets different aspects of each language area and vary in difficulty based on the complexity of the linguistic material used. In higher rounds of each level, the feedback is given after the wrong potion is given to the monster and it becomes stronger by growing another head.

A sample of the linguistic aspects covered in each round is provided in Table 13.

	Level 2: Phonemes	Level 3: N of syllables
Round 1	phoneme-to-written word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cv-cv, cv-v, v-cv, cv-vc
Round 2	letter-to-pronounced word: 2-syll, initial: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cvc-cv(c), vc-cv(c)
Round 3	phoneme-to-written word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cv-ccv(c), ccv-cv(c)
Round 4	letter-to-pronounced word: 3-syll, initial: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: ccvc-cv(c), cv-cccv(c),
Round 5	phoneme-to-written word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: v-cccv(c)
Round 6	letter-to-pronounced word: 2-syll, internal: /sp/,/st/,/sk/,/pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cv-cv, cv-v, v-cv, cv-vc
Round 7	phoneme-to-written word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cvc-cv(c), vc-cv(c)
Round 8	letter-to-pronounced word: 3-syll, internal: /sp/,/st/,/sk/, /pr/,/tr/,/kr/,...	1, 2 and 3-syllable words containing: cv-ccv(c), ccv-cv(c)
Round 9	letter-to-pronounced word: ευ:/ev-ef/, αυ:/av-af/	1, 2 and 3-syllable words containing: ccvc-cv(c), cv-cccv(c),
Round 10	letter-to-pronounced word: εϋ: /eɪ/, οϋ: /oɪ/, αϊ: /aɪ/	1, 2 and 3-syllable words containing: v-cccv(c)
Round 11	letter-to-pronounced word: οῧ: /oi/, αῗ: /ai/	

Table 24 Language covered by each round – Greek version

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum rate of failed attempts in each round, which is set as 20%.
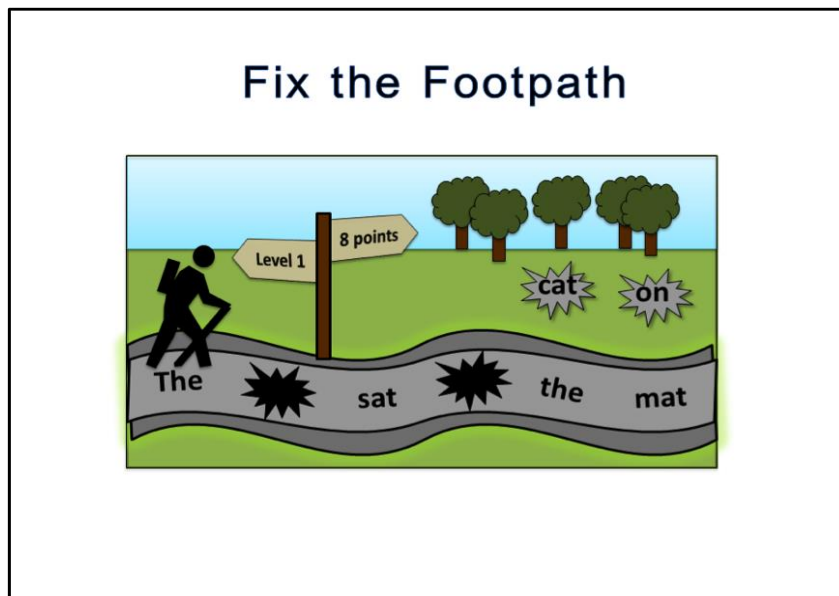
Language materials

Words
Phonemes
Suffixes

Linguistic input

Lists of words or parts of words categorized by useful rules (e.g. suffixing rules, types of vowels, etc.)

B.2.5. Fix the footpath (cloze)

Brief description

The child is presented with a road they need to travel on to achieve a goal but the road is full of holes. To cross the road, the player needs to fill the holes. Each segment (step) of the road is represented by words or parts of words (forming sentences or words). The child has a pile of words or parts of words that fit in the holes. She needs to fill in the holes in order to pass over the road.

Language

English & Greek

Language area/Difficulty:

English:
[3] Suffixing
[4] Prefixing
[9] Confusing letter shapes

Greek:
[4] Derivational suffixing
[5] Inflectional suffixing
[6] Prefixing
[8] Grammar: function words

Educational information

Learning outcomes

Build words from stems and affixes
Realise the meaning and role of word constituents (morphemes)
Build phrases and sentences
Process function words and their role in a sentence

Teaching strategies

Multi-sensory approach:
Use of images, variable font colour and size; visual discrimination of shapes.

Bottom-up teaching approach:
Language relations are made explicit through feedback.

Detailed description

Scenario

The child is introduced in the scenario of the game through a short animation. The character is a man that moves along a footbath, which has a few holes on it. The child has to fill in the holes with the appropriate blocks so as to help the man walk on the path without falling inside a whole.
-   A series of footpath blocks are in a random order across the grass.
-   At the top right corner of the screen, there are two blocks containing the words "cat" and "on".
-   Along the footpath there are two holes where the footpath blocks need to be placed. The rest of the footpath is marked with a short phrase and the holes are in the place of two of the words of the phrase, which are missing.
-   The instructions state "Use the blocks to complete the sentence to fix the footpath and help the man"
-   The score is set at 0
-   An animated finger taps on the "cat" block and drags it into the second position. Then, it drags the "on" block into the first position.
-   The man begins to walk along the footpath.
-   As the "on" block is in the incorrect place, when the man walks onto it, he falls inside and his body disappears inside the hole while the head is still showing with an angry face.
-   The incorrect word or phrase is pronounced so that the child can hear his/her mistake.
-   Score is decreased to -1
-   The blocks move back into their starting positions
-   The man gets out the hole and goes back to the beginning of the footpath.
-   The finger appears again and drags the "cat" block into the first position. The "on" block is moved into the second position.
-   The man begins to walk along the footpath and gets to the other side.
-   The character performs a celebratory dance and the score is increased to 0
-   The screen scrolls left, revealing the next footpath the character needs to cross
-   The blocks now contain the characters "bat", "rat" and "sat"
-   The footpath states "The" <hole> "and the " <hole> <hole> "on a mat"
-   After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

The game is completed after a number of levels, which cover language content of increasing difficulty:

Level	Categories on cauldrons	Language
1	Words (syllables)	English / Greek
2	Words (stems and affixes)	English / Greek
3	Phrases	English / Greek

Table 25 Structure of each level

Game play

- A man, footpath and set of blocks appear as above.
- Along the footpath, a series of holes highlight where the blocks need to be placed
- Each hole is larger than the building blocks such that the placement of the blocks does not need to be that exact. The block expands to fill the gap when placed in the footpath hole.
- Voice instructions are played explaining that the blocks need to be put in the holes to allow the character to walk along a series of footpaths. These instructions match the visual instructions also displayed. The play button on the instruction bar will replay these speech instructions.
- When the activity is started, an integer is passed in, indicating the language area being addressed.
- The game is completed in three levels, each of which consists of a number of "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- The rounds vary in difficulty based on the number of holes within the footpath (Table 26) and the number of available blocks.
- Each level also varies in difficulty based on the content shown on each block (as seen in Table 26) and the time limit set to complete it.

Level	Number of rounds	Number of holes/words	Content on each block	Time limit
1	9	10 (2 holes per footpath)	syllables	No time limit
2	15	16 (2 holes per footpath)	affixes (prefixes or suffixes)	Time limit per round
3	20	26 (2 holes per footpath)	function words (e.g. articles, prepositions etc.)	Time limit per footpath

Table 26 Properties of each round

- If the block is moved within the constraints of a hole, it "clicks into place" within that hole
- The block can be moved out of a hole back to the shelf or into another whole.
- As soon as all of the holes are filled, the child has to tap on an "OK" button so that the character will start to walk over them. At this point, touching the screen has no impact until the footpath is under consideration.
- If all of the blocks are placed in the correct order, the character successfully crosses the footpath and character performs a celebratory dance.
- The score is increased by 1.
- If this was not the last footpath within the round, the screen scrolls left, revealing the next footpath the character needs to cross.
- If the blocks are placed in an incorrect order, the walk walks on the incorrect block and falls inside the hole, while his head is still showing with an angry face (or unhappy or dizzy).

- The score is decreased by 1 and the man walks back to the beginning of the path.
- The child has a second attempt to change the positions of the blocks.
- In round 2:
- Once the time limit for the entire round has been reached, a pop-up appears stating "Time's up!"
- The game progresses to the third round
- In round 3:
- Once the time limit for a given word has been reached, a pop-up appears stating "Time's up!"
- The screen scrolls left, revealing the next footpath the character needs to cross.
- When the last footpath in the last round is crossed, after the appropriate feedback is given, a pop-up screen appears with a highlight of the difficulty being addressed, the number of footpaths correctly crossed (e.g. 14/30), the time taken to play, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.
- If this is the last footpaths but there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of footpaths correctly crossed (e.g. 8/10), the time taken to play and a "Continue to next round" button.

Progression rules

Within each level, each round targets different aspects of each language area and vary in difficulty based on the complexity of the linguistic material used. In higher rounds of each level, there are more available blocks than the number of holes in the footpath.

A sample of the linguistic aspects covered in each round is provided in Table 27.

	Level 3: Grammar: function words Words included on blocks	
	Content on path	Content on blocks
Round 1	Short phrases: ART – N – 'and' – ART – N	definite articles, conjunctions ('and')
Round 2	Short phrases: ART – ADJ – N – 'and' – ART – N	indefinite articles, conjunctions ('and')
Round 3	Short phrases: ART – ADJ – N - ART(gen) – N(gen) – PRO(gen) (e.g. "το μικρό αυτοκίνητο του αδερφού μου")	definite articles, pronouns
Round 4	Short sentences: ART – (ADJ) – N / PRO – VERB – ART – (ADJ) - N	definite/indefinite articles, pronouns
Round 5	Short sentences: ART – (ADJ) – N / PRO – VERB – ART – (ADJ) – N – ART(gen) – N(gen) – PRO(gen)	definite/indefinite articles, pronouns
Round 6	Longer sentences with 'and' or 'but'	definite/indefinite articles, pronouns, conjunctions
Round 7	Longer sentences with adverbial clauses	definite/indefinite articles, pronouns, adverbials ('when', 'after' etc.)
Round 8	Longer sentences with complement clauses	definite/indefinite articles, pronouns, complementisers ('that', 'if' etc.)
Round 9	Longer sentences with relative clauses	definite/indefinite articles, pronouns, relative pronouns ('who', 'which' etc.)

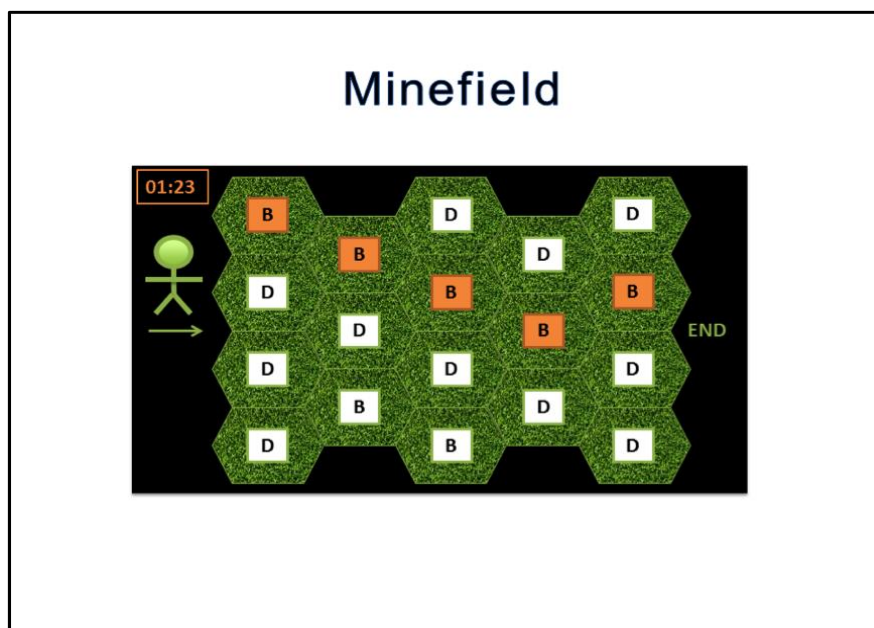**Table 27 Language covered by each round – Greek version**

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum rate of failed attempts in each round, which is set as 20%.

Language materials

Words
Syllables
Suffixes
Sentences

B.2.6. Minefield

Brief description

A mine field appears as a grid of hexagonal tiles with each tile labeled with a word, letter, pattern. The player is given instructions to cross the minefield safely by tapping only the tiles that fit a rule/pattern. When the player taps the correct tile, a character (figure representing player) is placed on that tile. If the player taps the wrong tile, the figure explodes (and the player loses and life - one of three). The player can only jump to an adjacent field, a jump to a removed will simply give feedback that the jump is too far. The previously jumped tiles remain highlighted to create a route. There is only one correct path through the minefield.

Language

English & Greek

Language area/Difficulty:

English:
[2] Vowels sounds
[5] Grapheme-phoneme correspondence
[6] Letter word / patterns
[8] Irregular/sight words
[9] Confusing letter shapes

Greek:
[2] Phonemes: consonants
[3] Phonemes: vowels
[7] Grapheme-phoneme correspondence
[9] Word recognition difficulties: Sight words/ Irregular words
[10]   Letter (visual) similarity

Educational aspects

Learning outcomes

- Identify letter shapes
- Establish and enhance grapheme-phoneme correspondences on a (multisyllabic) word
- Identify word patterns (sight words, irregular words)
- Acquire regularity in phonemes/letters alternation (word level)

Teaching strategies

<u>Multi-sensory approach:</u>
Use of images, variable font size; visual discrimination of patterns; rhythmic alternation

<u>Bottom-up teaching approach:</u>
Language relations are made explicit through feedback.

Detailed description

Scenario

When opening the application, the first thing to appear is an instructional animation.
- Hexagonal tiles appear on a four by five grid with a player character to the left of the minefield
- Each tile contains a background image of grass and an image of a "mine" which has a letter marked on it (on the image of all the mines, letters with similar shapes are shown).
- The player character has to get across the minefield following only one determined route.
- The instructions give a question and three possible answers (words) are shown in the screen: Which one of these is an animal? cup, hat, cat.
- The player character choose the correct one and the correct route is highlighted.
- The words are moved out of the screen and the route is no more highlighted.
- An animated finger appears and taps on the tile marked with the letter "k" in the first column. The player moves onto the tile:
    - o i. An explosion graphic appears covering that tile and an explosion sound is played
    - o ii. A pop-up appears saying "Wrong move. Try again", this is the "k" but cat needs "c"; then, the tile with the indicated letter is highlighted.
- The animated finger then taps on the "c" tile in the first column, which is then highlighted. The finger then taps on the tiles "a" and "t" tiles in the second and third columns. The tiles are then highlighted and the player moves onto them in succession.
- The player steps off the minefield
- A pop-up appears saying "Well done for navigating your way across the minefield"
- The minefield turns into a beautiful flower garden.
- After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

- The game is completed after a number of 5 levels, which cover language content of increasing difficulty:
- (Unique matches are required for cards)
- Within language level we increase difficulty by asking player to beat previous time. Each time a player plays, time is recorded and displayed the next time.

- To further increase difficulty, the field can be made longer. At first the whole field is displayed (if longer than a screen), to start playing the screen zooms in on a smaller number of tiles.
- The game is completed after a number of 5 levels, which cover language content of increasing difficulty:

Level	Minefield tiles	Language
1	Phonemes: vowels, consonants (sound similarity)	English / Greek
2	Letter (visual) similarity	English / Greek
3	Grapheme-phoneme correspondence	English / Greek
4	Word recognition difficulties: Sight words, Irregular words	English / Greek
5	Letter word pattern	English
	Grammar / function words	Greek

Table 28 Structure of each level

Game play

- Hexagonal tiles appear on a four by five grid for the first round (as in the screen shot)
- Each tile contains a background image of grass and an image of a "mine" which also has content marked on it
- A player character also appears to the left of the minefield
- Sound instructions are played explaining what mines are safe to stand on. The play button on the instruction bar will replay these speech instructions.
- A timer begins. The timer ends when the character has successfully navigated across the minefield. This time is stored in the logger, is used as an indication of success. It may also be shown to the user during an initial pop-up to highlight how long it took them to play the game the last time they played.
- When the activity is started, an integer is passed in, indicating whether the language area being addressed.
- Each level consists of three "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is:
  o The rounds vary in difficulty based on the length of the route necessary to get across the minefield
  o The first round has the shortest route of having a four by five grid of tiles
  o For the second and third rounds, the field becomes longer, scrollable in a manner similar to angry birds where swiping along the field moves which portion of the field you can view
  o The second round has a medium route of having a four by ten grid of tiles 2. The third round has the longest route of having a four by fifteen grid of tiles.
- Each round consists of matching the same type of content. New content is selected for each round and the underlying difficulty may change.
- In the first round the child has to form a word, selecting the tile with correct letters; in the second one, the child has to form a word by selecting the correct syllables; in the third round, the child forms a phrase by selecting the tile with the correct word.
- The player character starts in column 0 (where there is no content)

- A player can only select tiles which are on the column equal to or one higher than the current column.
- While the player character is in column 0, any tile in the first column may be selected
- Subsequently, the player can only select tiles which are adjacent to the current tile the player character is on. Tiles which are adjacent to, but in a previous column, cannot be selected.
- The selection of that tile is then assessed. If it is a correct tile, and not in the last column, the tile which the player has selected is highlighted as being yellow (the grass background is replaced with a yellow colour).
- If the tile is correct and in the last column,
  o If this is the last round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to play the game, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.
  o If there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to play the round and a "Continue to next round" button
- If the tile is incorrect, an explosion graphic appears covering that tile and an explosion sound is played. A pop-up appears saying "Wrong move. Try again"
  o a. The round re-sets itself by moving the player character back to column 0 (off the minefield) and the tiles reset to their starting position. The round starts again.
  o b. Every third time the player gets blown up within this round they are given the option of exiting the game or continuing to play.
  o

Progression rules

Within each level, each round targets different aspects of each language area and vary in difficulty based on the complexity of the linguistic material used. In higher rounds of each level, there are more available blocks than the number of holes in the footpath.

A sample of the linguistic aspects covered in each round is provided in Table 29.

	Level 3: Grammar: function words	
	Content on path	Content on tiles
Round 1	Short phrases: ART – N – 'and' – ART – N, ART – ADJ – N – 'and' – ART – N	definite articles, conjunctions ('and')
Round 2	Short phrases: ART – ADJ – N - ART(gen) – N(gen) – PRO(gen) (e.g. "το μικρό αυτοκίνητο του αδερφού μου"), ART – (ADJ) – N / PRO – VERB – ART – (ADJ) - N	definite/indefinite articles, pronouns
Round 3	Short sentences: ART – (ADJ) – N / PRO – VERB – ART – (ADJ) – N – ART(gen) – N(gen) – PRO(gen)	definite/indefinite articles, pronouns

**Table 29 Language covered by each round – Greek version**

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum rate of failed attempts in each round, which is set as 20%.

Language materials

Words
- Letters (always include confusing ones but also include other "easy" ones)
- List of words annotated by phonemes matched with corresponding letters
- List of vowels marked as long/short (fixed list - 20, dipthongs also marked as long)
- Recording of pure sounds (phonemes, linked to the grapheme)
- List of words tagged with pattern (each pattern records whether it is positioned at beginning, middle, end)
- Words tagged as being irregular
- List of confusable letters - lowercase only
- List of commonly swapped letter sequences
- Word recognition (semantic errors)

B.2.7. Highlight Curling
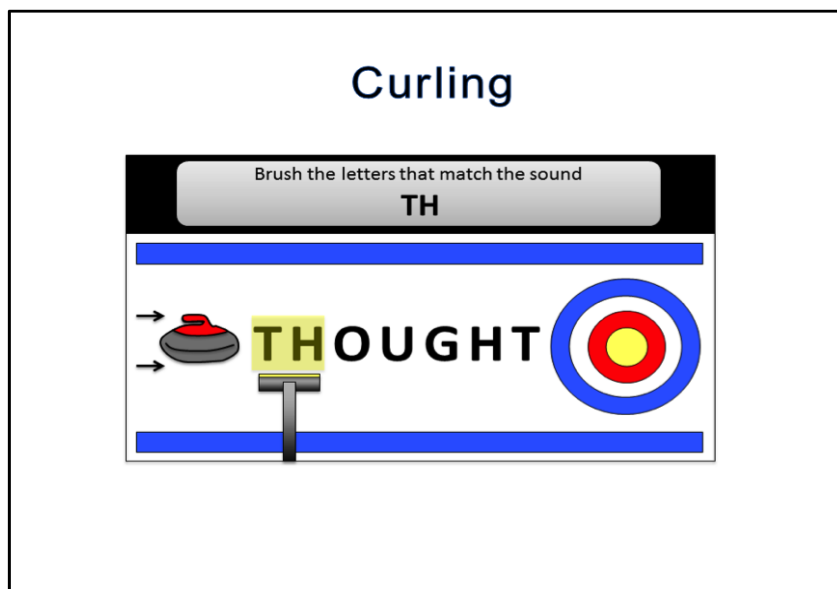
Brief description

This is a key activity to allow readers to make direct choices about patterns rather than choose from predefined prompts.

The students are presented with a curling sheet (official name for the ice track) and a number of curling stones. The curling sheet has words or sentences written on it. The player slides the stone but needs to brush the sheet in the right places to guide the stone along. The right places are determined by a pattern (either read out or presented in writing). The places where the player has brushed are highlighted. Brushing in the right places speeds up the stone and brushing in the wrong places slows it down. The place of the brush is also highlighted in blue when it speeds up the stone and sandy texture when it slows it down.

Language

English & Greek

Language area/Difficulty (Coded Integer):

English
[1] Syllable division
[2] Vowel sounds
[3] Suffixing
[4] Prefixing
[9] Confusing letter shapes

Greek
[1] Syllable division
[2] Phonemes: Consonants
[3] Phonemes: Vowels
[4] Derivational suffixing
[5] Inflectional suffixing
[6] Prefixing
[9] Word recognition: Sight / Irregular words

Educational aspects

Learning outcomes

- Automate syllabification
- Automate letter shapes
- Automate common morphemes (suffixes and prefixes) in different words

Teaching strategies

Multi-sensory approach:
Use of images, variable font size; visual discrimination of patterns; rhythmic alternation

Bottom-up teaching approach:
Language relations are made explicit through feedback.

Detailed description

Scenario

When opening the application, the first thing to appear is an instructional animation
- The animation contains a smaller version of the visual aspect of the game
- A curling stone appears to the left of the screen, a word in the centre and a target zone to the right.
- The brush moves and highlights the letters "HT" and the end of "thought".
- The brush moves to hover over the stone and the stone begins to slide
- When it reaches the "HT" the stone speeds up, hits the wall behind the target and bounces back past the starting position to off the screen: i. A pop-up appears saying "Wrong letters!"
- The word "thought" is replaced with the word "think"
- The brush moves and highlights the letters TH at the beginning of the word
- The brush moves to hover over the stone and the stone begins to slide
- When it reaches the TH the stone speeds up and settles on the centre of the target
- A pop-up appears saying "Well done for brushing the correct letters"; the word "thought" is confirmed auditory and visually.
- After the tutorial animation has completed, two buttons appear. The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

The game is completed after a number of game levels, which cover language content of increasing difficulty.

Level	Words on the ice track	Language
1	Vowels	English
2	Syllable division	English / Greek
3	Letter (visual) similarity/ Confusing letter shapes	English / Greek
4	Prefixing	English / Greek
5	Derivational suffixes	English / Greek
6	Inflectional suffixes	Greek
7	Word recognition difficulties: Sight words, Irregular words	English / Greek

Table 30 Structure of each game level

Game play

- A pop-up appears noting the number of words the player got correct in the game the last time they played
- The number of stones needed for the current round are lined up along the bottom of the screen
- Instructions are provided explaining what letters need to be brushed to reach the target. The format of these instructions are different across the three rounds.
- When the activity is started, an integer is passed in, indicating the language area being addressed.
- Each game consists of three "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- The rounds vary in difficulty based on the number of words being played and the way in which instructions are given.
-

Round Number	Number of words used within the round	Presentation of the instructions
1	10	Visual and sound
2	16	Visual only
3	26	Sound only

Table 31 Properties of each game round

- Each round consists of matching the same type of content. New content is selected for each round and the underlying difficulty may change.
- The stone starts to the left of the word need to be brushed
- The player can only select individual letters to be highlighted – when tapping on the area around the letter, the brush highlights a rectangle around it. Free-form highlighting cannot occur.
- When the stone is tapped on, it begins to move. Once it is moving, touching the stone has no effect.
- When the stone moves over any highlighted letter it speeds up
- If the correct letters have been highlighted, the stone slides to a halt in the centre of the target and the correct word is confirmed auditorily and visually.
- If the incorrect letters have been highlighted, the stone does not stop in the target but hits the wall behind it, bounces back and slides off the edge of the screen to the left; the incorrect word

breaks down into small scattered stones. An animation highlights the error and explain the reason why it is incorrect.
- At the end of each round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of words correctly highlighted and a "Continue to next round" button
- At the end of the last round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of correctly highlighted words, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.

Progression rules

Content is selected based on the difficulty being addressed. In addition to the word being set ("full word"), the graphemes which need to be highlighted are also set ("grapheme pattern"). The grapheme pattern must only appear once within the full word otherwise it is not possible to determine whether the correct letters have been highlighted or not.

The Greek words are considered of high and low frequency use and customized according to the number of two and three-syllables (see .the list of 500 high and low frequency words).

Round Number	Number of words used within the round	Presentation of the instructions
1	10 three-syllable low frequency words	Visual and sound
2	20 three-syllable low frequency words	Visual only
3	20 three-syllable low frequency words	Sound only

**Table 32 Structure of each round**

Scoring

Points are received for the distance the stone travels, all wrong brushes slow down the stone until it stops and the throw has to be repeated. The sheet also has a final goal and the speed with which that goal is achieved can gain additional points.

Note: In real curling, sweeping can be used to slow down the stone, as well as speed it up to achieve position rather than distance, but that would complicate our aim and require too much game learning.

Language materials

Words
Suffixes Letter patterns
Graded list of words
Words tagged with their morphological structure

B.2.8. Typing train dispatcher
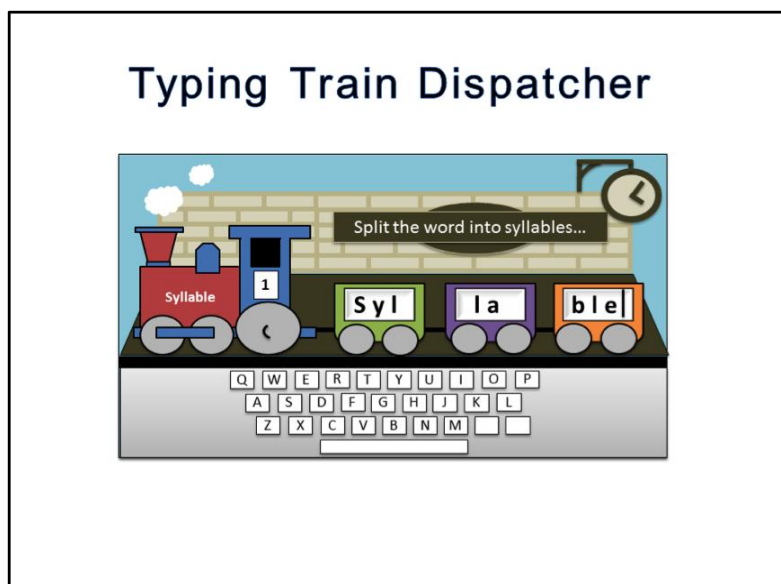
Brief Description

The player is shown a train station and given the task of loading and dispatching trains from it as fast as possible to avoid collisions. To dispatch a train, the player has to load it with the appropriate cargo. To load the cargo, the player uses the keyboard to type the appropriate language into each carriage. For instance, if the player is presented with the word "syllable" (by voice, writing or both), they tap the first carriage and type in 'syl', then the second, type in 'la', etc. This same thing can be done with letters, sounds (i.e. all letters representing a sound would fit in the carriage), suffixes or whole words.

Language

English/Greek

Language area/Difficulty

English:
[1] Syllable division
[3] Suffixing
[4] Prefixing
[5] Grapheme-phoneme correspondence
[8] Irregular/sight words
[9] Confusing letter shapes

Greek:
[1] Syllable division
[4] Derivational suffixing
[5] Inflectional suffixing
[6] Prefixing
[8] Grammar: Function words
[9] Word recognition: Sight / Irregular words

Educational aspects

Learning outcomes

- Identify word pattern
- Identify word decomposition and identify morphemes (suffixes and prefixes)
- Identify and decode sight and irregular words
- Segment and blend words
- Automate grammar rules

Teaching strategies

- Multi-sensory approach:
    Use of images, variable font size; visual discrimination of patterns; rhythmic alternation
- Bottom-up teaching approach:
    Language relations are made explicit through feedback.
- Metalinguistic awareness:
    The player is asked to judge his/her own response and reflect on own performance.

Detailed Description

Scenario

- When opening the application, the first thing to appear is an instructional animation.
- A series of three train carriages are pulled in from the left behind a train engine.
- The train has the word "syllable" written on it.
- The first train carriage is highlighted.
- The letters s, y and l are highlighted on the keyboard and are typed out into the first carriage
- The second train carriage is highlighted.
- The letters l, a and b are highlighted on the keyboard and are typed out into the second carriage.
- The train begins whistling and a red arrow appears over the third carriage with the message "check that this carriage is loaded correctly".
- The error is highlighted with another colour and made explicit to the player.
- The second carriage is highlighted and the content is cleared
- The letters l and a are highlighted on the keyboard and are typed out into the second carriage.
- The third train carriage is highlighted.
- The letters b, l and e are highlighted on the keyboard and are typed out into the third carriage.
- The word "syllable" no longer appears on the train
- The player is asked to type out the word "syllable" and the word appears on the train
- The train then pulls the carriages off screen to the left
- At the same time, the instructions disappear, replaced with the message "Well done – first railway wagon loaded correctly".
- A set of two train carriages are pulled in from the left by a new train which has the word "making" written on it
- After the tutorial animation has completed, two buttons appear.
- The "Replay" button causes the animation to play again, the "Start Game" button sends us to the main activity.

Levels

The game is completed after a number of game levels, which cover language content of increasing difficulty.

Level	Content on train carriages	Language
1	Letters	English / Greek
2	Syllables	English
3	Prefix+base	English / Greek
4	Stem+siffix (English) Stem + derivational suffix (Greek)	English / Greek
5	Stem + inflectional suffix (Greek)	Greek

Table 33 Structure of each game level

The scoring can be done either by the number of trains dispatched or by visually decreasing the pile of cargo that needs to be loaded. The difficulty can be increased by language and within language by the speed with which new trains are approaching. When the train isn't loaded in time, the next train crashes into it and the player has to start again.

Game play

- A timer starts and an empty station appears.
- Sound instructions are played explaining that the words on the trains need to be split into the different carriages to allow the train to continue.
- These instructions match the visual instructions also displayed on the station sign. The play button on the instruction bar will replay these speech instructions.
- When the activity is started, an integer is passed in, indicating the language area being addressed.
- The game can only use three lengths of words – two carriages, three carriages or four carriages.
- The only game-action a player can make is to select a carriage.
- The other two actions are to listen to the instructions again and to play the sound element on the train carriage.
- When a carriage is tapped on, it is highlighted:
    a. The contents of that carriage is deleted,
    b. A keyboard pops-up,
    c. Any characters typed on the keyboard are placed into the carriage up to the size limit of the carriage
- As soon as all of the carriages are filled, the system checks whether each carriage holds the correct graphemes or set of graphemes.
- If all of the carriages are correctly filled, the train pulls the carriages off screen to the left.
- At the same time, the instructions disappear, replaced with the message "Well done – train loaded correctly"
- Over each carriage which is incorrectly filled a red arrow appears
    o The message "Check that this carriage is loaded correctly" appears above the red arrow(s) and a pop-up appears recommending to the use of the appropriate resource of rules or explanations about the incorrect filling.
- When the last train in the last round is completed, after the appropriate feedback is given, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to dispatch all of the trains, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.
- If this is the last train but there is another round, a pop-up screen appears with a highlight of the difficulty being addressed, the time taken to complete this round and a "Continue to next round" button

Progression rules

- Each game level consists of three "game rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- The rounds vary in difficulty based on the number of trains that need to be dispatched as shown in Table 34.
- Each round also varies in difficulty based on the content shown on the train (as seen in Table 35).
- The sound aspect of the train necessitates a play button placed on the train.

Round Number	Number of trains/words trains	Content on each carriage
1	10	Visual and sound
2	20	Visual only
3	20	Sound only

Table 34 Properties of each round

Round Number	Number of trains/words trains	Content on each carriage
1	10 three-syllable high frequency words	Visual and sound
2	20 two-syllable low frequency words	Visual only
3	20 three-syllable low frequency words	Sound only

Table 35 Properties of each round

In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum rate of failed attempts in each round, which is set as 20%.

Language materials

Words annotated with the appropriate segments
Sentences selected on appropriate difficulty
Grammar rules
Words
Syllables
Suffixes
Sentences

B.2.9. Syllable / suffix karate chops

Brief Description

A character dressed in Ninja/Judo costume appears. A word appears with a suffix or prefix or is two syllables. Player needs to swipe at the correct boundary. Ninja then does a karate chop to split the word. If the swipe was in the correct place, the word splits and Ninja bows and gets ninja shooting stars. The resulting word is read out. If the swipe was wrong, the word doesn't split and the Ninja starts jumping about holding is hand. A player gets 2 goes at each word (one with each hand), the word disappears and no points are awarded.

As the word difficulty progresses, the materials changes from wood, brick, concrete, marble to metal. Players can also get a higher colour belt as they get more points. Difficulty of game increases based on the amount of time ninja has to perform the chop.

Language

English & Greek

Language area/Difficulty

English:
[1] Syllable division
[3] Suffixing
[4] Prefixing

Greek:
[1] Syllable division
[4] Derivational suffixing
[6] Prefixing

Educational aspects

Learning outcomes

- Syllabify
- Perform word decomposition and process inflectional and derivational suffixes
- Identify different morphemes (suffixes and prefixes) in sight and irregular words
- Build words from affixes and suffixes

Teaching strategies

Multi-sensory approach:
Use of images, variable font size; visual discrimination of patterns; rhythmic alternation

Bottom-up teaching approach:
Language relations are made explicit through feedback.

Detailed description

Scenario

- When opening the application, the first thing to appear is an instructional animation.
- A wooden block with a word on it drops down from the top of the screen.
- A karate character walks in from the right of the screen.
- A dotted line appears between the letter "h" and "e".
- The line becomes solid.
- The character walks over and strikes the block where the line is
- An "Ouch" pop-up appears and when it fades out the karate character jumps around holding his hand.
    a. Another pop-up appears stating "Wrong place to hit"
    b. The score is decreased by 1
- A karate teacher appears and explains (auditorily or visually) why the chop place was wrong. The character walks back to the right of the word block.
- A dotted line appears between the letter "p" and "f" and the line becomes solid.
- The character walks over and strikes the block where the line is.
- The word splits and slides apart.
- The karate character takes a bow.
- The score is increased by 1
- The word slides to the left of the screen and becomes part of the "broken" word list
- After the tutorial animation has completed, two buttons appear.
- The "Replay" button causes the animation to play again the "Start Game" button sends us to the main activity.

Levels

Each game is developed in three game levels, each of which consists of three "rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
The rounds vary in difficulty based on the number of words being played in each round (Table 36).

Level	Language	Round Number	Number of words used within the round	Time limit
1	Syllable: N of syllables	1	10	No time limit
		2	16	Time limit for the round
		3	26	Time limit for each word
2	Prefixing: words with prefixes (nouns/adj./verbs)	1	10	No time limit
		2	16	Time limit for the round
		3	26	Time limit for each word
3	Suffixing: words with suffixes: (nouns/adj./verbs)	1	10	No time limit
		2	16	Time limit for the round
		3	26	Time limit for each word

Table 36 Structure of each game level

Game play

- A pop-up appears noting the number of words the player got correct in the game the last time they played and how long it took for them to play the game last time
- - Instructions are provided explaining how many sections the words need to be split into; both root and suffix/prefix or into syllables. If splitting syllables, need to make clear how many splits need to be made – one split for two syllable words and two splits for three syllable words.
- - When the activity is started, an integer is passed in, indicating whether the difficulty being addressed is syllable division (value 1), suffixing (value 3) or prefixing (value 4).
- a. Based on the difficulty, content is selected (two-three syllable words / nouns, adjectives, verbs)
- The character starts to the right of the word needing to be split. There is an area to the left of the screen where "broken" words are displayed.
- A player can only select individual spaces between letters. When tapping the area around the letter a dotted line appears. This "snaps" into place between letters as the finger moves across the screen. If the finger taps on an area of the screen with no letters on it, no dotted line is visible:
- When a finger is removed from the screen:
    - o If there is a dotted line between two letters, the line becomes solid.
    - o If the line is in the correct place for a split, the line becomes solid.
    - o The character walks over and strikes the block where the line is.
    - o The word splits and slides apart.
- If there are no more splits to make:
    - o The karate character takes a bow.
    - o The score is increased by 1.
    - o The word slides to the left of the screen and becomes part of the "broken" word list.
    - o The character walks back to his starting position.
- If there are more words to split then the next one falls down from the top of the screen.

- If there are more splits to make:
    o A pop-up appears stating that the word needs to be split again.
    o The character walks back to the right of the word block ready to try and split the word again.
    o If the line is not in the correct place for a split
- An "Ouch" pop-up appears and when it fades out the karate character jumps around holding his hand.
- Another pop-up appears stating "Wrong place to hit" and the score is decreased by 1.
- The character walks back to the right of the word block ready to try and split the word again.
- -At the end of each round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of words correctly split, the time taken to complete the round and a "Continue to next round" button
- At the end of the last round, a pop-up screen appears with a highlight of the difficulty being addressed, the number of correctly split words, the time taken to complete the game, a motivational message (such as "Great work on matching all the letter shapes"), a "replay" button and an "exit" button.

Progression rules

- Each game level consists of three "game rounds". Each round progresses in difficulty independently of how hard the linguistic difficulty is.
- As the player progresses through rounds, a time limit is given for the whole round (Round 2) or for each word (Round 3).
- Once the time limit has been reached, a pop-up appears stating "Time's up!" and the game progresses to the next word/round.
- In order to progress from one round to the next, the child has to achieve a specified success rate. This is defined as a minimum rate of failed attempts in each round, which is set as 20%.

Language materials

Words
List of two syllable words
number of syllables
two–three segments
list of affixed words
prefix/suffix
rules for suffixing
transition of deploying the rule
transitive - goes both ways on and off

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